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UNITED STATES DEPARTMENT OF THE INTERIOR
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UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary

FISH AND WILDLIFE SERVICE
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The Progressive Fish-Culturist

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TABLE OF CONTENTS

Page

Ulcer Disease in Brook Trout (Salvelinus fontinalis): Its Economic Importance, Diagnosis, Treatment, and Prevention
-- S. F. Snieszko 43

Relationships of Weight and Body Measurements of Adult Smelt, Osmerus mordax (Mitchill)
-- W. D. Baten and P. I. Tack 50

Echo Sounding Massachusetts' Lakes, Ponds, and Reservoirs
-- R. H. Stroud and Frank Grice 56

Propagation of Largemouth Black Bass and Bluegill Sunfish in Federal Hatcheries of the Southeast
-- John Blosz 61

Biotin, Pantothenic Acid, and Brown Trout
-- A. M. Phillips, Jr., D. R. Brockway, F. E. Lovelace, and G. C. Balzer, Jr. 67

Survival and Growth of Stocked Lake Trout Yearlings From Seneca and Raquette Lake Breeders
-- D. C. Haskell, R. G. Zilliox, and W. M. Lawrence 71

A Rapid Presumptive Test for Furunculosis in Fish
-- P. J. Griffin 74

A Comparison of the Growth of Fingerling Chinook Salmon Reared in Ponds, Troughs, and Circular Tanks
-- H. E. Johnson and A. C. Gastineau 76

Rate of Survival of Largemouth Black Bass Fingerlings Stocked in Experimental Farm Ponds
-- W. H. Brown 79

Egg Inventory: Enumeration With the Egg Counter
-- D. C. Haskell 81

Items

Lake Trout Production and Estimate of Losses Resulting From Sea Lamprey Depredations 49

Argulus Outbreaks in Minnesota Lakes 70

A Quickly Changed Brush Clamp 73
Chloretone Used To Anesthetize Salmon Fingerlings 78
Milton C. James Retires 84
John L. Kask, New Assistant Director 84

Clearing House 83

ULCER DISEASE IN BROOK TROUT *(SALVELINUS FONTINALIS)*:

ITS ECONOMIC IMPORTANCE, DIAGNOSIS, TREATMENT, AND PREVENTION

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OUTBREAKS OF ULCER DISEASE in brook trout in the northeastern part of the United States have been described during the past half century. During the last several years the incidence of ulcer disease seems to have increased so much that a number of private hatcheries, specializing in the culture of brook trout, have had to discontinue operations or raise other species of trout. At the Leetown Hatchery of the Fish and Wildlife Service, all fingerling brook trout were lost because of ulcer disease during the 3 years extending from January 1, 1948, through 1950.

A review of the research conducted on this disease shows that the term "ulcer disease," which was first used by Marsh (1905), is a general term. Diseases of brook trout having symptoms identical with or very similar to those described by Marsh were reported in Europe by Hofer (1904) and in the United States by Moore (1924), Fish (1934), and Wolf (1939, 1941). None of these authors claimed the discovery of the cause of this disease. The presence of bacteria in the lesions was reported regularly, but only Fish (1934) made successful isolations. However, Fish expressed doubt as to whether any of the bacterial species which he isolated (including Pseudomonas hydrophila) could be considered as the agent of this disease. The question of the etiology of the type of ulcer disease described by these authors remained unsolved until Hemophilus piscium was isolated by Snieszko and Friddle (1950) and subsequently described by Snieszko, Griffin, and Friddle (1950). This organism had been found regularly in all outbreaks of ulcer disease investigated by these authors in the northeastern part of the United States. Frequently, ulcer disease was complicated by furunculosis; in such cases, Bacterium salmonicida was also present.

Ulcer disease can be reproduced in all its symptoms by starting an epizootic among fingerling brook trout under controlled laboratory conditions with a pure culture of H. piscium (Snieszko, Griffin, and Friddle, 1952). Therefore, it is suggested that the term "ulcer disease" be restricted to the fish disease caused by H. piscium and having the symptoms and pathology described by Marsh (1905), Fish (1934), and Wolf (1939).

Other types of fish diseases which are characterized by the appearance of external ulcerations, but that apparently are caused by other etiological agents or by causes still unknown, have also been described. Calkins (1899) reported on an ulcer disease caused by a sporozoan Lymphosporium truttae. Hofer (1904) and Plehn (1924) described ulcerations which appeared on fish as the result of other or unknown causes. Reed and Toner (1941, 1942) described a "red sore" disease of pike (Esox lucius) and brook trout and isolated Pseudomonas hydrophila from the infected fish. P. hydrophila is a common water bacterium that may cause heavy mortalities in many species of fishes and in other cold-blooded animals (Schaperclaus 1941). Griffin and Snieszko (1951) described a bacterium causing ulceration and general infection in aquarium fishes.

Various species of marine fishes that had superficial ulcerations were caught in the North Sea, both near and far from the shore (Johnstone 1922, Riddell and Alexander 1912). These authors described septic ulcers from which several species of bacteria were isolated, but the experiments were not carried far enough to establish the relationship between these bacteria and the ulcerations found in marine fishes. Fish that had external ulcers were also caught by fishermen in the brackish waters of the New England States.

ECONOMIC IMPORTANCE OF ULCER DISEASE

The destructive and contagious nature of this disease is obvious, as entire populations

of fingerling brook trout can be killed within several weeks after an outbreak of this infection. The susceptibility of brook trout to ulcer disease seems to decrease with age. The progress of the disease is slower among trout 1 to 4 years old or older, as some of these trout never develop the disease and others become infected but recover. However, the trout which do recover have dark scars, and this lowers their market value. Brown trout (Salmo trutta) are more resistant, and therefore the progress of infection is slower and the losses are not so great as among the brook trout. Brown trout also respond better to treatment with antibiotics (Gutsell, unpublished data). Rainbow trout are resistant to ulcer disease. H. piscium was isolated from only a very few sick adult rainbow trout at Leetown. All of these mortalities occurred in adult trout after the taking of spawn, an indication that the handling of fish and the resulting injuries probably lowered the resistance of the fish to infection. The same condition has been found during outbreaks of furunculosis among adult rainbow trout.

According to recent observations (Snieszko, Friddle, and Griffin, 1951; Snieszko, Griffin, and Friddle, 1952), ulcer disease can be successfully treated with antibiotics. However, such treatment is expensive and, without drastic sanitary measures, cannot protect fish from recurrences of the disease. Frequently, ulcer disease is complicated by a simultaneous outbreak of furunculosis. When such mixed infections are present, the losses are usually greater and occur at a faster rate than if caused by ulcer disease alone.

DIAGNOSIS

The symptoms of ulcer disease have been described in great detail by Fish (1934) and Wolf (1939). According to Fish:

> ... the earliest lesion of ulcer disease appearing on the body surface of an infected host is a definite thickening of the epithelium over a small area producing an inconspicuous white patch. This patch, which may measure 0.5 to 5.0 millimeters, rapidly loosens from the body surface and produces a picture not unlike a very small growth of the fungus Saprolegnia. Such a condition is best described as an "epithelial tuft." ...

The appearance of the tuft is followed by perforation or erosion of the skin and the formation of a small ulcer. A typical ulcer is usually well defined, circular, shallow, dark red or gray. There may be several large ulcers or many small ulcers, and sometimes they coalesce and produce large irregular eroded areas. The lesions or ulcers may also appear on fins. Such a lesion destroys the soft tissue between the fin rays, leaving the more durable rays projecting beyond necrotic tissue. Wolf (1939) noticed that ulcers are frequently formed on the edges of the jaws and roof of the mouth. Trout with ulcers in the mouth do not take food and therefore cannot be treated by oral administration of drugs. In extremely acute outbreaks the external symptoms may be absent. Among the internal symptoms, the most marked is the congestion of the posterior section of the gut, but this symptom also occurs in furunculosis and other fish diseases. Sometimes symptoms of ulcer disease are similar to those of furunculosis, and these two diseases may be confused.

The only reliable method of diagnosis is by bacteriological examination. The type of ulcer disease here described is caused by Hemophilus piscium. This bacterium can be grown only on media supplemented with extracts from animal or plant tissues which are sterilized by filtration and not with heat. Griffin (1951, 1951a) found that the growth factors required by this bacterium are cocarboxylase (diphosphothiamine) and/or adenosine triphosphate. Hemin is markedly stimulating. These compounds can be used instead of tissue extracts or fish peptone. Media of variable composition can be used with good results. The medium used in the Microbiological Laboratory at the Leetown Station (post office, Kearneysville) has the following composition:

Proteose peptone No. 3 (Difco)	5.0 grams
Tryptic digest of casein	5.0 grams
Yeast extract	5.0 grams
Maltose	5.0 grams
Sodium chloride	2.5 grams
Agar	15.0 grams (or more)
Distilled water	1 liter
pH ..... (about)	6.8

As needed, the medium should be dissolved. When the temperature of the medium is not higher than 65° C., it should be enriched by the addition of 5 percent of fish peptone (Snieszko et al. 1950). Cocarboxylase and hemin can be used instead of fish peptone to enrich the medium. Cocarboxylase should be sterilized by filtration and added in the

quantity of 5 micrograms per milliliter of sterile medium. Hemin can be incorporated in the medium before sterilization in the autoclave at a rate of 10 milligrams per liter of medium.

For bacteriological examination, the medium should be prepared in the form of slants in test tubes or, whenever possible, should be poured in petri plates. Live fish which have ulcers, furuncles, or other lesions should be selected for examination. If typical ulcers are present, some material should be scraped from the ulcer without surface disinfection (Friddle, unpublished observation) and the medium should be inoculated in such a manner that the bacteria will have enough room to grow as separate colonies. If the material is removed from a closed lesion (furuncle), from blood, or by insertion of an inoculating needle to the kidney and the dorsal vein, the surface of fish should be disinfected and the excess of disinfectant should be removed with, for example, a cotton swab that has been moistened in ethyl alcohol (about 75 percent). The most reliable results can be obtained by the inoculation of two types of media, one containing the growth factors previously listed and the other without supplement. After 2 to 3 days of incubation at 22° to 25° C., if H. piscium is present, small, whitish dull colonies should appear on the surface of the medium to which the supplements were added. Such colonies should be transferred to slants of medium with and without supplement.[1/] If the isolated bacteria will grow only on the enriched medium, the presumptive test for the presence of H. piscium may be considered as positive.

Bacterium salmonicida, the cause of furunculosis, grows well on the same medium without the addition of any special supplement; however, a special medium is somewhat better. For the methods of diagnosis of furunculosis, the reader is referred to a paper by Gutsell and Snieszko (1949) and to a paper now in preparation by Griffin, Snieszko, and Friddle.

TREATMENT AND PREVENTION

The early attempts to treat ulcer disease with various disinfectants and drugs (including sulfonamides) were mostly unsuccessful (Tunison and McCay 1937; Wolf 1939, 1941, 1947; Leetown Hatchery, unpublished data). The preliminary studies (Snieszko, Friddle, and Griffin, 1951) and additional detailed studies (Snieszko, Griffin, and Friddle, 1952) have shown that two of the new antibiotics, terramycin[2/] and chloramphenicol[3/] (chloromycetin) were very effective in the treatment of ulcer disease. Both these antibiotics can be mixed with the fish diet and given orally. The minimum effective dosage is 50 milligrams of pure "antibiotic activity" per kilogram of body weight of fish per day (2.25 grams per 100 pounds). At this time, chloramphenicol and terramycin are still expensive; therefore, their use in the treatment of fish diseases may have to be quite limited. There is a likelihood that terramycin, which is extracted from another microorganism, may be available in a crude and therefore less expensive form for treatment of fish diseases. When an antibiotic is used in a crude form, its concentration in the crude product must be known in order to obtain the correct dosage based on the pure "antibiotic activity." To be certain that the dosage is adequate and to provide a wide margin of safety, it may be better to increase the dosage to 75 milligrams per kilogram of body weight per day (3.35 grams per 100 pounds of fish).

The treatment should be started as soon as possible after the outbreak of the disease, as those individual fish with advanced stages of infection may be unable to take the medicated food. All visibly sick fish should be removed and destroyed because they may not be saved and very probably will serve as a reservoir of the pathogen.

The treatment should be continued until the epizootic is brought completely under control. This may be achieved after 10 to 15 days, provided that treatments are started soon enough. In cases of more advanced infection, the treatment should be continued until the mortalities due to the disease are reduced to zero. It must be kept in mind, however, that in a large population of apparently healthy fish there are continuous small losses due to various and usually undetermined causes.

Every effort should be made to diagnose the disease correctly. In those cases in which one suspects ulcer disease, furunculosis, or a mixed infection, a bacteriological

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1/Federal or State hatcheries located east of the Mississippi River can obtain media in the form of agar slants in test tubes, with and without supplements, from the Microbiological Laboratory at Kearneysville, West Virginia. Hatcheries located west of the Mississippi River should send requests to Dr. R. R. Rucker, North Pacific Fishery Investigations, 2725 Montlake Boulevard, Seattle 2, Washington.

2/Manufactured by Chas. Pfizer & Company, Inc., Brooklyn 6, New York.

3/Manufactured by Parke, Davis & Company, Detroit, Michigan.

examination should be made. Furunculosis can be treated with sulfonamides effectively and less expensively than by any other known method. In instances of ulcer disease or of a frequently occurring mixed infection with H. piscium and B. salmonicida, antibiotics should be used.

When terramycin is used for treatment, a more permanent control of the infection may be achieved by replacing terramycin with chloramphenicol during the last 4 to 6 days of treatment. Should drug-fast mutants of the pathogen appear during the treatment with terramycin, the use of another equally, or seemingly more, effective antibiotic like chloramphenicol may be greatly beneficial. It is believed that in the event of a mixed infection caused by H. piscium and B. salmonicida, sulfamerazine and terramycin or chloramphenicol can be given at the same time. Both should be given at the full dosage rate assumed on the basis of the information available on the sulfonamide therapy of furunculosis (Snieszko and Friddle 1951, 1952; Flakas 1950).

When employing antibiotics, as when treating furunculosis with sulfonamides, it is equally important to give all of the fish an opportunity to obtain an adequate amount of the drug. The distribution of antibiotics in the food should therefore be as uniform as possible. For best results and in terms of economy, the fish should be fed the drugs judiciously: neither more nor less food should be used than will be taken readily by the fish. The fish should be well graded, and the runts should be removed to insure a more equal consumption of medicated food. As most of the fish diets contain meat or other components which may spoil rapidly, the feed containing the drug should be prepared no more than 2 days in advance and should be stored under refrigeration.

Every possible sanitary measure should be taken to prevent the spread of disease to other parts of the hatchery. It is fortunate that now both furunculosis and ulcer disease can be cured, but this fact in no way should lead to the relaxation of measures which may prevent the outbreak or spread of these diseases. No drug can eliminate a disease completely from an entire population. A drug can only reduce losses when the disease strikes, and the incidental cost of treatment in money and labor is usually considerable. The only effective measure against frequent recurrence of infectious fish diseases is to eliminate all possible sources of infection.

Adult fish, even though they do not show symptoms of a disease, may frequently act as carriers of microorganisms which cause destructive epizootics among younger fish. The accepted practice of holding adult fishes away from fingerlings should therefore be strictly observed. Adult rainbow trout are particularly dangerous as carriers of ulcer disease and furunculosis. Even if infected with H. piscium, B. salmonicida, or both, rainbow trout may not show any symptoms of disease; nevertheless, they may serve as a constant source of infection. Therefore, because of the possibility of an outbreak of ulcer disease, furunculosis, or a mixed infection, it seems advisable to eliminate all adult trout from the hatchery and replace the brood stock with fish from a source which is known to be free from these diseases.

At the Leetown Station, furunculosis and ulcer disease were endemic for several years. Fingerling brook trout would remain uninfected as long as they were kept in the hatchery troughs. However, soon after transfer to the outside pools and exposure to indirect contact with adult rainbow trout--by water, nets, boots, seines, predator birds, and other means--the fingerling trout became infected with furunculosis, ulcer disease, or both. Sulfonamide therapy gave effective control of furunculosis, but the losses from ulcer disease were just as great among fingerling brook trout until the treatment with antibiotics was developed. When the adult trout were taken away, there were no more outbreaks of these diseases up to the time of preparation of this report (more than a year).

The treatment of ulcer disease with antibiotics, as well as the treatment of furunculosis with sulfonamides or antibiotics, is very effective (Snieszko, Griffin, and Friddle, 1952). If the treatment is started as soon as the first signs of ulcer disease appear, 70 to 80 percent of the trout can be saved. However, because treatment is given to a population of fishes, not on an individual basis, it is very likely that some individuals may not be cured completely and will serve as carriers. The available data indicate that treatment of ulcer disease with chloramphenicol may give cures of longer duration than treatment with terramycin.

A complete eradication of ulcer disease or furunculosis in a contaminated population of fishes is unlikely to result from the use of drugs or antibiotics. This is not surprising because the same is generally true with communicable diseases of humans, other animals, and plants. One can expect an effective and durable control of infectious

diseases only if therapy is coordinated with effective sanitation, immunization whenever practicable, breeding of resistant varieties, or a combination of these measures.

Allegory may not be out of place at this point. When a fire occurs because of faulty wiring or other causes, one can call the fire company to extinguish the blaze. The degree of damage done by the fire depends upon the speed and efficiency with which the fire is brought under control. A wise owner of property that has been damaged by fire will locate the original cause and remove it before another fire results. An even wiser owner, by preventive maintenance and the removal of all possible fire hazards, will minimize the likelihood of fire.

The same is true with infectious (fish) diseases. Treatments must be initiated as soon as possible in order to produce worth while results. After the progress of the disease is arrested, however, the source of the infection must be located and removed. Just as danger of fire can be reduced by constructing a fireproof building, the likelihood of an infectious disease can be reduced by the measures promulgated in this review.

The use of drugs for prevention of diseases can be rated as both a short- and a long-range measure. The short-range prophylaxis with drugs is usually effective and not too costly. This is in keeping with the statements of Burrows, who notes (1951) that in some hatcheries the pathogens (gill disease) or parasites may be present most of the time in the water supply, and that in such cases regular prophylaxis with drugs and disinfectant may be necessary. Prophylaxis with drugs is like pouring water on the roof of a house which stands near one which is ablaze. The action is stopped when the fire is brought under control, and the cost of such a temporary measure is not too great. If an infectious disease appears in one of the troughs, pools, or ponds in a hatchery or a fish farm, it may be prudent to use a dependable prophylactic treatment to protect uninfected fish until the outbreak of the disease is brought under control and the source of infection is located and eliminated. However, in the case of ulcer disease, furunculosis, and many other fish diseases, the long-range prophylaxis by means of frequent or constant treatments is time-consuming and expensive and may result in the appearance of drug-resistant strains of pathogens which will be much more difficult to control later. Also, many of the drugs may be of varying toxicity to the treated fish, causing mortalities or greatly affecting the growth rate of the fish (Gutsell and Snieszko 1949a).

It should be stressed that, regardless of the great therapeutic value of antibiotics in the treatment of ulcer disease of trout, these drugs, like all others, have limitations. Placing more reliance on their effectiveness than is justified on the basis of careful study, may be a cause of disappointment.

Nothing certain is known about the original source of H. piscium or about the nature of resistance and susceptibility of trout to this disease. At this time, we have only a few clues which will have to be evaluated in further investigations. There are several reports which show that superficial ulcers are fairly common among fishes in the North Sea and in the Atlantic Ocean. The first outbreaks of ulcer disease in America were reported in hatcheries on the Atlantic seaboard. However, frequent losses of considerable magnitude apparently occurred only during the last few years. As far as is known, the practice of using fresh or frozen marine fishes as trout food has increased during the last few years. It is also known that uncooked tissue of some fish is destructive to thiamine, also known as vitamin B_1 (Deutsch and Hasler 1943). Griffin (1951) reported that diphosphothiamine (cocarboxylase) is necessary for the growth of H. piscium. It is known that thiamine antagonizes the action of diphosphothiamine. Therefore, it is possible (hypothetically) that trout fed with raw fish may be more susceptible to ulcer disease.

One should bear in mind the possibility that eastern brook trout (Salvelinus fontinalis) may be getting more susceptible to ulcer disease, and perhaps also to furunculosis, as a result of breeding and development of early spawning, or fast-growing, strains (Wolf 1951). Embody and Hayford (1925) and Davis (1946) indicated that the breeding of resistant varieties is possible, and the research in this direction should be greatly expanded. The States of New York and Pennsylvania are building special hatcheries for this purpose.

It seems most appropriate to close this review with the following quotation from an article by Haas (1951):

> ... In fact it is not known just how or why an epidemic starts or fails to start in nature. Greenwood says: in plague, as in other sicknesses something more is needed to generate an epidemic

than even wide spread and quite uncontrolled means of infection.

REFERENCES

Burrows, R. E.
1951. The treatment frequency and concentration for adequate prophylaxis with pyridylmercuric acetate for the control of bacterial gill disease. Prog. Fish-Cult. 13 (4): 225-226.

Calkins, G. N.
1899. Report upon the recent epidemic among brook trout (Salvelinus fontinalis) on Long Island. N. Y. Comm. Fish, Game and Forests, Ann. Rept. 4 (1898) 175-189.

Davis, H. S.
1946. Care and diseases of trout. U. S. Fish and Wildl. Serv. Res. Rept. 12, 98 pp.

Deutsch, H. F., and Hasler, A. D.
1943. Distribution of a vitamin B_1 destructive enzyme in fish. Proc. Soc. Expt. Biol. Med. 45: 429-432.

Embody, G. C., and Hayford, C. O.
1925. The advantage of rearing brook trout fingerlings from selected breeders. Trans. Am. Fish. Soc. 55: 135-148.

Fish, F. F.
1934. Ulcer disease of trout. Trans. Am. Fish. Soc. 64: 252-258.

Flakas, K. G.
1950. Sulfonamide therapy of furunculosis in brown trout. Trans. Am. Fish. Soc. 78 (1948): 117-127.

Griffin, P. J.
1951. Some nutritional requirements of a new member of the genus Hemophilus (H. piscium). Ph.D. thesis, Yale Univ.
1951a. Cocarboxylase and adenosine triphosphate as growth factors for Hemophilus piscium. Arch. Biochem. 30 (1): 100-102.

------ and Snieszko, S. F.
1951. Unique bacterium pathogenic for warm-blooded and cold-blooded animals. U. S. Fish and Wildl. Serv. Fish. Bull. 52 (68): 187-190.

------ Snieszko, S. F.; and Friddle, S. B. A new adjuvant in the diagnosis of furunculosis in fish caused by Bacterium salmonicida. /In preparation/

Gutsell, J. S., and Snieszko, S. F.
1949. Dosage of sulfamerazine in treatment of furunculosis in brook trout, Salvelinus fontinalis. Trans. Am. Fish. Soc. 76 (1946): 82-96.
1949a. Response of brook, rainbow, and brown trout to various dosages of sulfamerazine. Trans. Am. Fish. Soc. 77 (1947): 93-101.

Haas, V. H.
1951. Disaster and disease. Jour. Wash. Acad. Sci. 41 (9): 277-284.

Hofer, B.
1904. Handbuch der Fischkrankheiten. München.

Johnstone, J.
1922. Septic ulcers in cod. Trans. Liverpool Biol. Soc. 36: 286-291.

Marsh, M. C.
1905. The Cold Spring Harbor epidemic among trout. N. Y. Forest, Fish and Game Comm. Ann. Rept. 10: 125-139.

Moore, Emmeline.
1924. Diseases of fish in State waters. N. Y. Cons. Comm. Rept. 13: 49-61.

Plehn, Marianne.
1924. Praktikum der Fischkrankheiten. 179 pp., illus. Nägele, Stuttgart.

Reed, G. B., and Toner, G. C.
1941. Red sore disease of pike. Canad. Jour. Res. 19 (section D): 139-143.
1942. Proteus hydrophilus infections of pike, trout, and frogs. Canad. Jour. Res. 20 (section D): 161-166.

Riddell, W., and Alexander, D. M.
1912. Note on the ulcerative disease of the plaice. Trans. Liverpool Biol. Soc. 26: 155-161.

Schaeperclaus, Wilhelm.
1941. Fischkrankheiten. Wenzel and Sohn, Braunschweig.

Snieszko, S. F., and Friddle, S. B.
1950. A contribution to the etiology of ulcer disease of trout. Trans. Am. Fish. Soc. 78 (1948): 56-63.

1951. Tissue levels of various sulfonamides in trout. Trans. Am. Fish. Soc. 80 (1950): 240-250.
1952. Further studies on factors determining tissue levels of sulfamerazine in trout. Trans. Am. Fish. Soc. 81 (1951): [In press.]

------ Friddle, S. B.; and Griffin, P. J.
1951. Successful treatment of ulcer disease in brook trout (Salvelinus fontinalis) with terramycin. Sci. 113 (2947): 717-718.

------ Griffin, P. J.; and Friddle, S. B.
1950. A new bacterium (Hemophilus piscium, n. sp.) from ulcer disease of trout. Jour. Bact. 59 (6): 699-710.
1952. Antibiotic treatment of ulcer disease and furunculosis in trout. Trans. N. Am. Wildl. Conf. 17: [In press.]

Tunison, A. V., and McCay, C. M.
1937. The nutrition of trout. Cortland Hatchery Report No. 6. N. Y. Cons. Dept., 24 pp.

Wolf, L. E.
1939. Observations on ulcer disease of trout. Trans. Am. Fish. Soc. 68 (1938): 136-151.
1941. Further observations on ulcer disease of trout. Trans. Am. Fish. Soc. 70 (1940): 369-381.
1947. Sulfamerazine in the treatment of trout for furunculosis and ulcer disease. Prog. Fish-Cult. 9 (3): 115-124.
1951. Selective breeding of trout. N. Y. State Conservationist 6 (1): 18.

LAKE TROUT PRODUCTION AND ESTIMATE OF LOSSES RESULTING FROM SEA LAMPREY DEPREDATIONS

(Great Lakes Fisheries Investigations, Fish and Wildlife Service, Ann Arbor, Michigan)

Comparison (by state or province) of the pounds and value of the lake trout production in Lakes Huron, Michigan, and Superior for 1950, with the modern normal for those waters and an estimate of losses resulting from sea lamprey depredations in Lakes Huron and Michigan

[Values computed at rate of 50 cents per pound]

Region	Normal catch[1]			1950 catch			Loss			Percentage loss in region[2]
	Pounds (3)	Value (4)	Percentage of total	Pounds (3)	Value (4)	Percentage of total	Pounds (3)	Value (4)	Percentage of total	
Michigan	6,390	$3,195	42	2,425	$1,213	47	4,185	$2,092	40	65
Wisconsin	3,075	1,538	20	616	308	12	2,517	1,258	24	82
Illinois	457	228	3	4	2	0	453	227	4	99
Minnesota	336	168	2	202	101	4	-	-	0	-
Indiana	126	63	1	-	-	0	126	63	1	100
U. S. total	10,384	5,192	68	3,247	1,624	63	7,281	3,640	70	70
Ontario	4,991	2,496	32	1,922	961	37	3,180	1,590	30	64
Grand total	15,375	7,688	100	5,169	2,585	100	10,461	5,230	100	68

1/ Periods of years on which the modern "normal" catches are based: Canadian waters of Lake Huron, 1923-1939; U. S. waters of Lake Huron, 1895-1939; Lake Michigan, 1927-1944; Canadian waters of Lake Superior, 1930-1949; U. S. waters of Lake Superior, 1926-1949.

2/ Based entirely on losses of production in Lakes Huron and Michigan; differences between the 1950 and the normal catches in Lake Superior are not interpreted as gains or losses.

3/ Thousands of pounds. 4/ Thousands of dollars.

Brook and brown trout grow at about the same rate after being planted. The number of 10-inch brown trout appearing in the creel exceeds the number of 10-inch brook trout because the former species is less easily induced to take the hook--and therefore lives longer.

RELATIONSHIPS OF WEIGHT AND BODY MEASUREMENTS OF ADULT SMELT, *OSMERUS MORDAX* (MITCHILL)

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IN THE COURSE OF A STUDY of the utilization of smelt and other fishes, measurements of total length, standard length, and weight were made. It was concluded that this would be an excellent opportunity to study the relationships of weight and body measurements of these fish. The study had just been initiated when the catastrophic mortality of smelt occurred in the Great Lakes, a mortality resulting in the almost complete disappearance of this species from these waters. Only 51 smelt were obtained during 1943; the remainder were taken during 1948, when the smelt had returned in appreciable numbers.

Van Oosten (1937) has given an account of the stocking and dispersal of the smelt, Osmerus mordax (Mitchill), in the Great Lakes. The smelt was first recorded as taken from Lake Michigan in 1923; the smelt is considered to have originated from the 1912 planting of eggs in Crystal Lake, Michigan. Beckman (1942) has presented the weight-length relationship for adult smelt from Crystal Lake, whence the Great Lakes smelt population is presumed to have arisen.

Creaser (1925) and Hankinson and Hubbs (1922) have also given accounts of the establishment of the smelt in the Great Lakes. Schneberger (1937) has discussed the biological and economic importance of the smelt of Green Bay.

Materials and Measurements

The smelt used in this study were obtained by purchase from commercial fishermen of Green Bay in the vicinity of Escanaba, Michigan. The smelt measured were the regular run of the commercial catch.

Two measurements were added to those being taken for the utilization study. These were the maximum dorsoventral depth of the body and the maximum width of the body. These measurements were taken with special care to prevent any compression of the body. The first set of measurements was made on March 14, 1943, on fish taken on March 12, 1943, and kept on cracked ice in the interim. The second set of measurements was made on March 8 and April 21, 1948.

Weights were taken to the nearest tenth of a gram on a torsion balance, and the other measurements were made to the nearest millimeter. The sexes of the first shipment were represented in the ratio of 37 males to 14 females; for the second shipment this ratio was 122 males to 113 females.

Linear Relationship of Male Smelt

It is assumed in the first part of this study that weight is a linear function of body measurements or that weight is related to length, width, and thickness by the equation,

$$W = a + bx + cy + dz, \tag{1}$$

where W, x, y, and z represent respectively weight, standard length, depth, and thickness; and a, b, c, and d are constants which are to be obtained from the data. By applying to these data the method of least squares, given in all elementary books on statistics,

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This paper has been approved as Journal Article No. 724 (N.S.) Michigan Agricultural Experiment Station, East Lansing, Michigan.

this equation was found to be

$$(2) \qquad W = -53.319 + 3.892x + 8.012y + 3.036z \pm 2.07 \text{ gm.}$$

The standard error of estimate of this linear relation is 2.07 grams, which is 8.2 percent of the mean (25.29 grams) of the smelt measures. This measure of scatter of the weight measurements about the "plane" would be considerably smaller if the measurements of the three or four largest fish were omitted from the calculations. The size of the error of estimate indicates that one can predict the weight of a smelt from equation (2) and, on the average, be within 2.07 grams of its true weight about 68 percent of the times: this shows that this predicting equation is very good. In some biological work investigators are satisfied with estimate equations having an accuracy of 10 percent of the mean. In the case of the smelt, the accuracy is greater.

The equations in table 1 are linear relations between weight and various combinations of the body measurements. In each instance the standard error of estimate is given to show the accuracy of the equation.

The sizes of the standard errors of estimate show that weight can be predicted more accurately by using all three of the body measurements than by using any two of them or by using only one of them. The estimated weight obtained from the standard length and thickness is a little less accurate than that obtained from standard length and depth. The weight estimated from standard length is almost as accurate as the weight obtained from standard length and thickness. Standard length appears to be the most important measurement for estimating weight: standard length gives more accurate results than depth and thickness, as can be seen by examining the two errors of estimate. These measures of dispersion indicate rather definite associations between weight and body measurements.

Nonlinear Relationships of Male Smelt

In this part of the study it is assumed that weight is a product of the body measurements, each raised to a power or exponent. This equation is

$$(3) \qquad W = ax^by^cz^d, \text{ or}$$

$$\log W = \log a + b(\log x) + c(\log y) + d(\log z),$$

where x, y, z, and W are as before; and a, b, c, and d are another set of constants to be found. By applying the method of least squares to the given equation in logarithms, this equation is found to be

$$(4) \qquad W = 0.1005(x^{1.7553})(y^{0.8533})(z^{0.2800}) \pm 2.11 \text{ gm.}$$

Here the error of estimate, 2.11 grams, was obtained by finding the expected weight of each fish from equation (4) and then finding the difference between the actual weight and the predicted weight. Seventy-four percent of the observed weights are within one standard error of estimate of the predicted weights. About 66 percent of the errors are less than 2 grams. Equation (4) is not so accurate for predicting as equation (2), as can be seen by comparing the two errors of estimate.

The equations listed in table 2 indicate the relationships between weight and various combinations of body measurements. When the standard errors of estimate are examined, it is seen that weight can be estimated a little better from standard length and depth than from any other two measurements.

Many research workers with fish believe that weight and length are related by an equation of the form,

$$(5) \qquad W = ax^3,$$

where the length is raised to the third power. This equation for these measurements is

$$(6) \qquad W = 0.009133x^3 \pm 2.82 \text{ gm.}$$

This equation can be compared with the equation,

$$(7) \qquad W = ax^b = 0.0118x^{2.9025} \pm 2.81,$$

by examining table 2. The standard errors of estimate are about the same, indicating that one equation is about as accurate as the other.

Other Relationships

Table 3 exhibits the associations between various body measurements of male smelt. When these equations and their errors of estimate are examined, it is seen that standard length can be estimated about as accurately from depth as from depth and thickness.

The standard length of smelt can be estimated much more accurately than the weight of this fish. All of the errors of estimate for standard length are less than 5 percent of the mean length: this was not true for weights.

TABLE 1.--Equations for predicting weight of male smelt

Measurements	Predicting equation[1/]	Standard error of estimate	Error as percent of mean weight
x, y, and z	$W = -53.319 + 3.892x + 8.012y + 3.036z$	2.07	8.2
x and y	$W = -53.887 + 4.108x + 8.907y$	2.11	8.3
x and z	$W = -53.798 + 4.499x + 10.047z$	2.34	9.3
y and z	$W = -32.936 + 13.008y + 17.142z$	3.02	11.9
x	$W = -55.074 + 5.765x$	2.51	9.9
y	$W = -28.646 + 21.925y$	3.41	13.5
z	$W = -26.253 + 33.688z$	3.55	14.0

[1/] W = weight, x = standard length, y = depth, z = thickness.

TABLE 2.--Predicting equations for weight of male smelt

Measurements	Equation[1/]	Standard error of estimate	Error as percent of mean weight
x, y, and z	$W = 0.1005(x^{1.7553})(y^{0.8533})(z^{0.2800})$	2.11	8.3
x and y	$W = 0.0647(x^{1.9168})(y^{0.9964})$	2.13	8.4
x and z	$W = 0.0721(x^{2.0967})(z^{0.7444})$	2.45	9.7
y and z	$W = 5.189(y^{1.2898})(z^{0.9498})$	3.03	12.7
x	$W = 0.0118x^{2.9025}$	2.81	11.2
y	$W = 3.7760y^{2.0870}$	3.41	13.5
z	$W = 10.8700z^{1.9480}$	3.52	13.9
x^3	$W = 0.009133x^3$	2.82	11.2

[1/] W = the predicted weight.

The association between depth and thickness is usually good, as the size of the standard error of estimate indicates.

Correlations

The following values are correlation coefficients between various measurements of male smelt:

$r_{wx} = 0.920$ $R_{w \cdot xy} = 0.945$
$r_{wy} = 0.846$ $R_{w \cdot xz} = 0.931$
$r_{wz} = 0.832$ $R_{w \cdot yz} = 0.926$
$r_{xy} = 0.767$ $R_{x \cdot yz} = 0.832$
$r_{xz} = 0.813$ $R_{w \cdot xyz} = 0.951$
$r_{yz} = 0.813$

when w, x, y, and z represent respectively weights, standard length, depth, and thickness. These values verify that the given linear equations are rather accurate for estimating one measurement from one or more other measurements. The first three correlation coefficients indicate respectively that there is a definite association between weight and standard length, weight and depth, and weight and thickness. The next two coefficients show respectively that standard length is highly correlated with depth and thickness. The value 0.813 indicates a close association between depth and thickness. The values in the second column point out definite associations between weight and two body measurements and between weight and three body measurements.

TABLE 3.--Relationships between various body measurements of male smelt

Measurements	Equations[1/]	Standard error of estimate	Error as percent of the mean
x, y, and z	$X = 5.234 + 1.290y + 3.616z$	0.565	2.2
x and y	$X = 6.139 + 3.171y$	0.655	2.6
x and z	$X = 5.897 + 5.257z$	0.595	2.4
y and z	$Y = 0.514 + 1.272z$	0.141	0.6

[1/] X = predicted standard length; Y = predicted depth.

All of these latter correlation coefficients are large and differ very little from unity, which represents perfect correlation.

Comparison of Linear and Nonlinear Relationships

It is interesting to compare the three equations for estimating weight from standard length. These three equations are:

$$W = -55.074 + 5.765x \pm 2.51 \text{ gm.}$$

$$W = 0.0118x^{2.9025} \pm 2.81 \text{ gm.}$$

$$W = 0.00913x^{3} \pm 2.82 \text{ gm.}$$

The first equation, together with the scatter diagram, is plotted in figure 1. This chart shows the association between standard length and weight.

These three curves are plotted in figure 2, which shows how near each is to the other two. For the interval from 11.7 centimeters to 17.0 centimeters, in which all of the standard lengths lie, the three curves are very close together: the vertical scale has to be greatly magnified in order that the three curves may be separated in the chart. All three curves fit the data very well. The error of estimate for the straight line is the smallest, indicating that of the three curves the straight line fits the data best. For these smelt one curve is about as good as each of the other two.

Linear Relationships of Female Smelt

Table 4 shows linear relationships between weight and body measurements of female smelt caught at the same time as the male smelt.

Examination of tables 1 and 4 reveals that there are considerable differences between the coefficients in the corresponding equations. These differences indicate that the linear relationships for male smelt are quite different from those for females. The sizes of the standard errors of estimate, expressed as percentages of the means, show that in

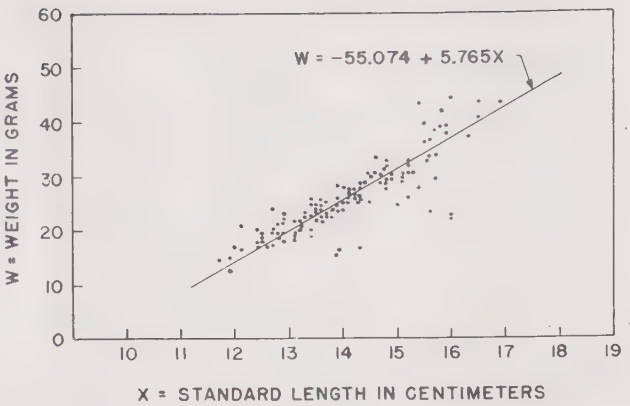

FIGURE 1.--Association between weight and standard length of smelt.

some cases the fits are better for the females than for the males--and in other cases the fits are better for the males. Both sets of equations fit the weights very well. The fits are best when standard length appears as one of the variables in the linear equations. For estimating weights, depth and thickness are not so good as standard length.

Nonlinear Relationships of Female Smelt

In table 5 are listed the nonlinear relationships between weight and body measurements of female smelts.

An examination of tables 2 and 5 shows that the coefficients in the corresponding equations are not the same. This indicates that the nonlinear relationships for male smelt are different from those for female smelt. It is interesting to note that the relationship between weight and the cube of the standard length is about the same for the males as for the females. These equations are

$$W = 0.009133x^{3} \pm 2.82 \text{ gm.}$$

for males.

$$W = 0.009198x^{3} \pm 2.99 \text{ gm.}$$

for females.

TABLE 4.--Linear relationships between weight and body measurements of female smelt

Measurements	Equations	Standard error of estimate	Error as percent of mean weight
w, x, y, and z	W = -68.483 + 4.890x + 6.493y + 6.003z	2.21	7.2
w, x, and y	W = -70.234 + 5.241x + 8.804y	2.25	7.3
w, x, and z	W = -66.073 + 5.037x + 13.886z	2.49	8.1
w, y, and z	W = -38.618 + 10.336y + 25.655z	4.63	15.1
w and x	W = -69.945 + 6.814x	3.00	9.8
w and y	W = -35.569 + 24.887y	5.41	17.7
w and z	W = -32.773 + 39.381z	4.94	16.1

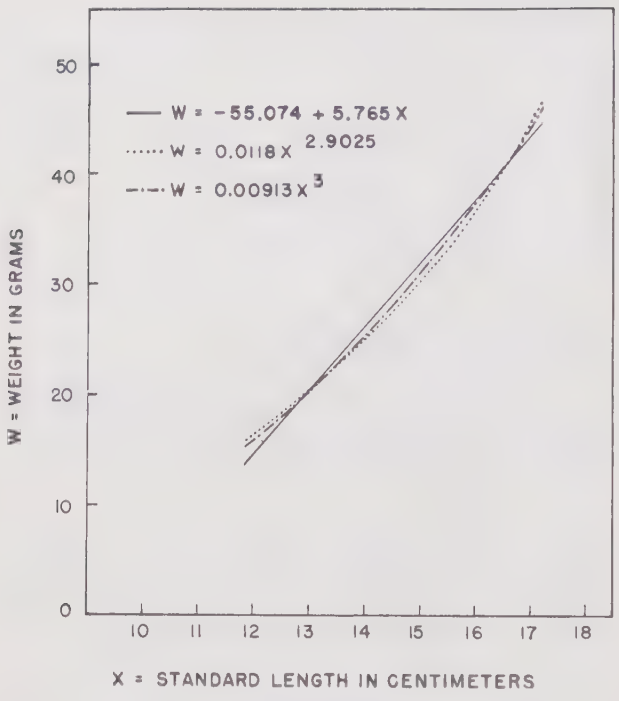

FIGURE 2.--Relationship between weight and standard length of male smelt.

There is not a great deal of difference between the nonlinear relationships of weight and standard length. These equations are

$W = 0.0118x^{2.9025} \pm 2.81$ gm. for males.

$W = 0.0068x^{3.1142} \pm 2.98$ gm. for females.

As for the males, the curves represented by the following three formulae nearly coincide for the interval in which the observed standard lengths are found:

$W = -69.0000 + 6.814x \pm 3.00$ gm.

$W = 0.0068x^{3.1142} \pm 2.98$ gm.

$W = 0.009198x^{3} \pm 2.99$ gm.

The sizes of the errors of estimate indicate that one curve fits the weight data about as well as the other two. If these three equations were plotted in the same graph, they would almost coincide for the interval in which the observed standard lengths lie.

Other Relations

Table 6 lists relationships between the body measurements.

There are considerable differences between corresponding equations in tables 3 and 6, indicating that the associations between body measurements for males are different from those for females. The sizes of standard errors of estimate show definite linear relations between the body measurements.

Correlation Coefficients

The following values are correlation coefficients between various measurements which pertain to female smelt. The letters w, x, y, and z represent the same values as for males.

r_{wx}	= 0.953	$R_{w \cdot xy}$	= 0.973
r_{wy}	= 0.839	$R_{w \cdot xz}$	= 0.972
r_{wz}	= 0.867	$R_{w \cdot yz}$	= 0.886
r_{xy}	= 0.739	$R_{w \cdot xyz}$	= 0.983
r_{xz}	= 0.796	$r_{w(xzy)}$	= 0.951
r_{yz}	= 0.868		

TABLE 5.--Nonlinear relationships between weight and body measurements of female smelt

Measurements	Equations	Standard error of estimate	Error as percent of mean weight
w, x, y, and z	$W = 0.0417(x^{2.1795})(y^{0.5639})(z^{0.3202})$	1.92	6.3
w, x, and y	$W = 0.0253(x^{2.3466})(y^{0.7703})$	2.03	6.6
w, x, and z	$W = 0.0456(x^{2.2807})(z^{0.7158})$	2.19	7.1
w, y, and z	$W = 7.1130(y^{0.8584})(z^{1.2533})$	4.28	14.0
W and x	$W = 0.0068x^{3.1142}$	2.98	9.7
W and x^3	$W = 0.009198x^{3}$	2.99	9.8
W and y	$W = 4.1610y^{2.0126}$	5.28	17.2
W and z	$W = 11.8900z^{1.9380}$	4.82	15.7

TABLE 6.--Linear relationships between body measurements of female smelt

Measurements	Equations[1/]	Standard error of estimate	Error as percent of the mean
x, y, and z	X = 6.203 + 0.800y + 3.996z	0.83	2.7
x and y	X = 6.604 + 3.066y	0.93	3.0
x and z	X = 6.617 + 5.058z	0.83	2.7
y and z	Y = 0.526 + 1.328z	0.20	0.6

[1/] X = predicted standard length; Y = predicted depth.

These large values indicate definite associations between these measurements on female smelt.

Relation of Weight and Product of Body Measurements

As the form of the body of a smelt with the caudal fin cut off is a modified ellipsoid, it was thought that the weight of smelt was related to the product of the standard length, the depth, and the width, or that the following equation would give good results for estimating weight:

(8) $$W = ax \cdot y \cdot z,$$

where a is a constant which has to be determined from the data. By the least squares method, this equation was found to be

$$W = 0.469xyz \pm 2.54 \text{ gm.}$$ for males.

$$W = 0.464xyz \pm 3.33 \text{ gm.}$$ for females.

As some of the equations for the relationships pertaining to the males differed from the corresponding equations for the females, it was a big surprise to find that the two equations just stated were almost the same. The standard error of estimate of the equation for the males is smaller than that for the equation pertaining to the females, indicating that this equation is better for estimating weights of males than for estimating weights of the females. Both equations are good predicting equations.

When a constant is used in these equations, or when an equation of the form

$$W = a + b(xyz)$$

is used for predicting weights, the following equations are obtained:

$$W = 3.075 + 0.415(xyz) \pm 2.41 \text{ gm.}$$ for males.

$$W = 3.865 + 0.411(xyz) \pm 3.07 \text{ gm.}$$ for females.

The slopes of these equations are almost identical: they differ in the third decimal place. The constants are not the same: they differ significantly because the weights of the females are larger than the weights of the males. These two lines are nearly parallel. One is above the other by 0.79 gram.

Literature Cited

Beckman, W. C.
1942. The length-weight relationships, age, sex ratio and food habits of smelt (Osmerus mordax) from Crystal Lake, Benzie County, Michigan. Copeia (2): 120-124.

Creaser, C. W.
1925. The establishment of the Atlantic smelt in the upper waters of Great Lakes. Pap. Mich. Acad. Sci., Arts and Lett. 5: 405-423.

Hankinson, T. L., and Hubbs, C. L.
1922. Establishment of smelt in the Great Lakes Waters. Copeia 109: 57-59.

Schneberger, Edward
1937. Biological and economic importance of smelt in Green Bay. Trans. Am. Fish. Soc. 66 (1936): 139-142.

Van Oosten, John
1937. Dispersal of smelt, Osmerus mordax (Mitchill), in Great Lakes region. Trans. Am. Fish. Soc. 66 (1936): 160-171.

"Specie" is still heard occasionally for a single "species" of fish.

ECHO SOUNDING
MASSACHUSETTS' LAKES, PONDS, AND RESERVOIRS

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Division of Fisheries and Game
Upton, Massachusetts

A STATE-WIDE BIOLOGICAL SURVEY of lakes, ponds, and reservoirs open to public fishing was initiated in Massachusetts in the summer of 1942. With the exception of 1943, this survey has been continued annually. The 400-odd individual waters currently subject to survey are usually more than 20 acres and average about 85 acres in surface area. About 65 percent are less than 100 acres in area, and 95 percent are less than 500 acres. Five percent exceed 500 acres; the largest thus far subject to survey is 1,721 acres. Only one of the lakes surveyed exceeded 100 feet in maximum depth. About 60 percent are less than 25 feet in maximum depth, 90 percent are less than 50 feet, and 98 percent are less than 75 feet in maximum depth.

The average number of water units surveyed annually by field parties from 1942 through the summer of 1950 was 31. During this period a party of five men was employed each summer. By the close of 1950, the Division of Fisheries and Game was under considerable pressure from sportsmen's groups to speed up the survey and bring it to an early conclusion. At this time the conduct of the survey came under the direction of the senior author. Intensive study of the 1950 operations revealed a number of ways in which the survey could be both speeded up and made more effective at the same time.

ECHO SOUNDING REPLACES HANDLINING

One of the more obvious weaknesses of the survey lay in the method of sounding to determine average and maximum depths. This method consisted of using handlines. On the average-sized body of water, two boats with two-man crews worked half a day to obtain a minimum number of soundings at approximately equal intervals over the entire surface. On larger lakes, a full day or longer was often required. Despite this substantial investment of man-hours, the results have been generally unsatisfactory from many standpoints. The average depths--of importance in reclamation work, for example--so obtained are highly erroneous.[1/] Figures of maximum depth secured by handlining are unreliable, as any depressions that may exist are found only accidentally. Ability to report authentic maximum depths is of great practical importance in establishing validity for the survey in the minds of sportsmen and riparian landowners. Furthermore, it has proved important to know the locations of drop-offs, bars, depressions, etc., in the various basins studied. Without more detailed information of this sort than handlining can provide, except at inordinate expense, it has proved difficult to undertake certain management activities or to provide useful suggestions for aiding anglers to harvest the fish crop more effectively.

It was decided, therefore, to secure a lightweight portable electronic depth-sounder in order both to provide more effective mapping of pond basins and to accelerate the process considerably at significant saving in manpower. It was reasoned that if mapping could be accomplished in the spring, prior to actual biological survey in summer, the field parties could be provided with accurate bottom-contour maps. This would achieve two purposes: (1) to aid in selection of fish sampling sites, and (2) to relieve substantial man-hours of labor that could be used

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1/ In North Pond, Florida, Berkshire County, average depth was calculated by handlining to be about 19 feet. Echo sounding indicated an actual average depth of about 12 feet. This pond was reclaimed by use of 360 pounds of 5-percent rotenone-bearing powders. Had the figure of 19 feet been used in the calculations, 210 pounds of this material would have been wasted in the belief that it was necessary to effect the desired concentration of toxic material.

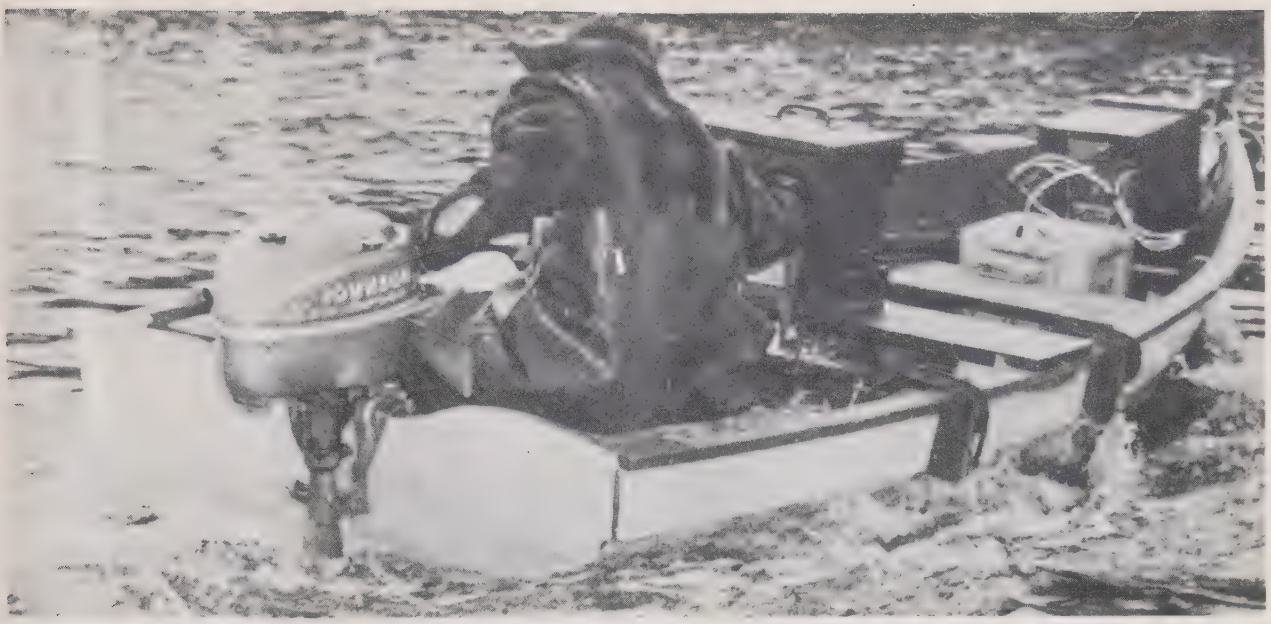


FIGURE 1.--The echo sounder in use. Note transformer in the bow, enclosed battery indicator dial, and side blocks to which underwater "fish" is clamped.

productively to permit more rapid movement from pond to pond.

Primarily because of the success of this plan, the survey achievement in 1951 was 108 ponds covered with two four-man field parties, a nearly fourfold increase in speed of coverage with only a 60-percent increase in personnel. Quality of work was not sacrificed in any way: on the contrary, far more voluminous and detailed information regarding the environment and fish population per unit surveyed was secured in 1951 than in any previous year. In terms of dollars, this has meant a saving of about $40,000, which is the estimated minimum cost differential of conducting the survey as before during the three additional seasons that would have been required.

Depth-sounding instruments have been used elsewhere in inland waters (Burrows 1949) although their use is not widespread. The device as employed in this instance, however, though portable, appeared somewhat cumbersome for ready portability and use by one man--as dictated by staff limitations and the large number and nature of individual units to be covered. A similar instrument was secured and utilized in a somewhat simplified rig.[2/] Because of the tremendous gain in efficiency and saving of funds made possible by utilization of this instrument in the pond and lake survey, the present authors have undertaken to describe its use in Massachusetts.

THE INSTRUMENT AND ITS MOUNTING

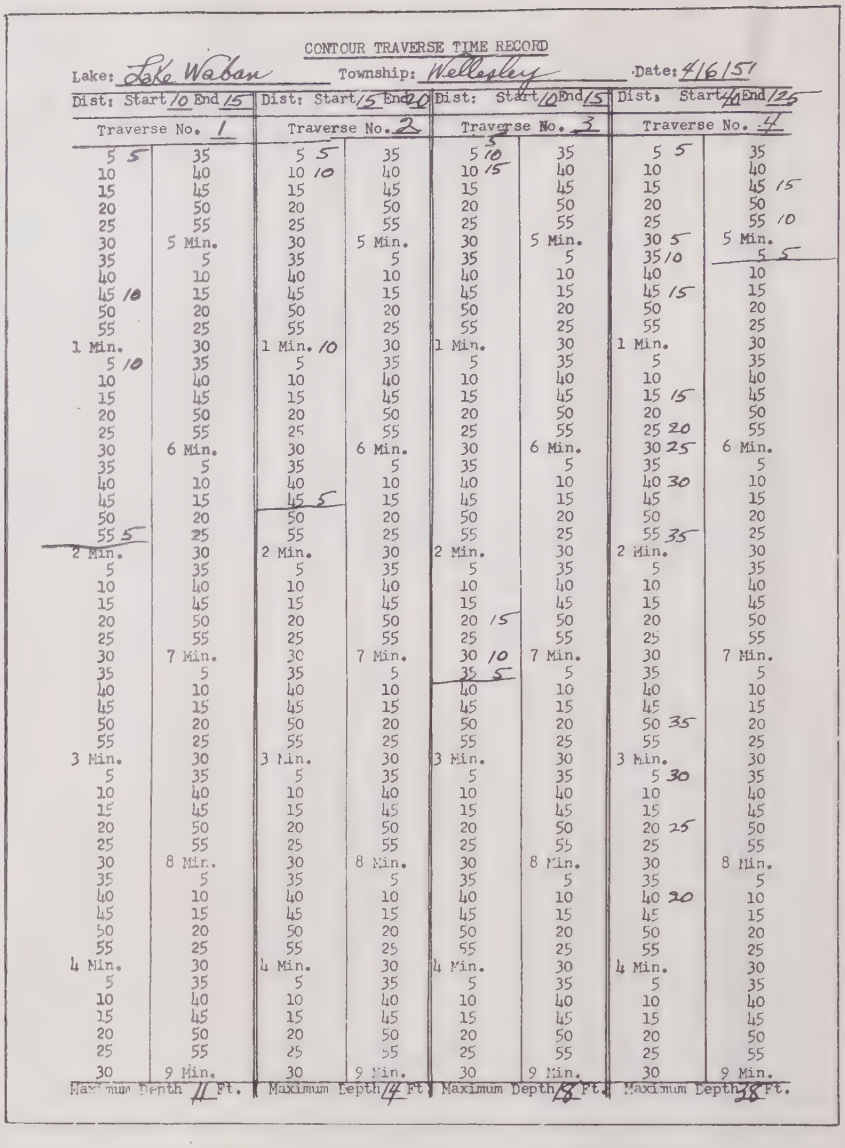
The instrument in question is similar to that employed by Burrows (1949) and is mounted on a 12-foot skiff as shown in figure 1. A 6-volt automobile storage battery is used as a source of power. This is located in the bow of the skiff in order partly to balance the weight of the operator, who rides on the stern seat. The battery is contained in a surplus navy ammunition box to prevent the acidification of any bilge water and excessive damage to the operator's clothing. The battery current is passed through a power unit (transformer) which provides an output of 110-volt, 60-cycle (± 0.2 cycle) alternating current for operation of the electronic components.

The transducer, housed in a water-tight indicator case, incorporates a three-stage tuned amplifier, which operates at 400 soundings per minute, and three receiving units. The power unit or transformer is located as far forward of the indicator case as possible (in the bow) to eliminate static interference. The indicator case is mounted on a board attached to the gunwales immediately forward of the operator.

The transducer is recessed into a roughly

[2/] The senior author instituted the use of echo sounding, developed the details of field use, and drew the final map. The junior author conducted most of the actual sounding and recording of field data. Credit is due Mrs. Ralph Woolner for laboratory computations.

FIGURE 2.--Time sheet used to record field data.



CONTOUR TRAVERSE TIME RECORD

Lake: Lake Waban Township: Wellesley Date: 4/16/51

Dist: Start 10 End 15	Traverse No. 1		Dist: Start 15 End 20	Traverse No. 2		Dist: Start 10 End 15	Traverse No. 3		Dist: Start 10 End 25	Traverse No. 4	
5 5		35	5 5		35	5 10		35	5 5		35
10		40	10 10		40	10 15		40	10		40
15		45	15		45	15		45	15		45 15
20		50	20		50	20		50	20		50
25		55	25		55	25		55	25		55 10
30	5 Min.		30	5 Min.		30	5 Min.		30 5		5 Min.
35	5		35	5		35	5		35 10		5 5
40	10		40	10		40	10		40		10
45 10	15		45	15		45	15		45 15		15
50	20		50	20		50	20		50		20
55	25		55	25		55	25		55		25
1 Min.	30		1 Min. 10	30		1 Min.	30		1 Min.	30	
5 10	35		5	35		5	35		5	35	
10	40		10	40		10	40		10	40	
15	45		15	45		15	45		15 15	45	
20	50		20	50		20	50		20	50	
25	55		25	55		25	55		25 20	55	
30	6 Min.		30	6 Min.		30	6 Min.		30 25	6 Min.	
35	5		35	5		35	5		35	5	
40	10		40	10		40	10		40 30	10	
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35	5		35	5		35 5			35	5	
40	10		40	10		40	10		40	10	
45	15		45	15		45	15		45	15	
50	20		50	20		50	20		50 35	20	
55	25		55	25		55	25		55	25	
3 Min.	30		3 Min.	30		3 Min.	30		3 Min.	30	
5	35		5	35		5	35		5 30	35	
10	40		10	40		10	40		10	40	
15	45		15	45		15	45		15	45	
20	50		20	50		20	50		20 25	50	
25	55		25	55		25	55		25	55	
30	8 Min.		30	8 Min.		30	8 Min.		30	8 Min.	
35	5		35	5		35	5		35	5	
40	10		40	10		40	10		40 20	10	
45	15		45	15		45	15		45	15	
50	20		50	20		50	20		50	20	
55	25		55	25		55	25		55	25	
4 Min.	30		4 Min.	30		4 Min.	30		4 Min.	30	
5	35		5	35		5	35		5	35	
10	40		10	40		10	40		10	40	
15	45		15	45		15	45		15	45	
20	50		20	50		20	50		20	50	
25	55		25	55		25	55		25	55	
30	9 Min.		30	9 Min.		30	9 Min.		30	9 Min.	
Maximum Depth 11 Ft.			Maximum Depth 14 Ft.			Maximum Depth 18 Ft.			Maximum Depth 38 Ft.		

stream-lined "fish," about 2 feet long by 4 inches square, built up by lamination. This is suspended on two 1/2-inch square brass support rods that are about 18 inches long and curved at their upper ends to hook over the gunwales amidships on the specially fitted blocks to which the rods are clamped. This permits the "fish" to be held rigidly some 6 inches below the surface while traveling at full speed with the transmitting and receiving surface of the transducer in the proper position for sounding.

The outfit is complete with at least two 6-volt auto batteries and an inexpensive battery charger on hand. It is advisable to use one battery one day--the battery will last a full 8 hours of continuous sounding--and be charging the second battery for the next day, thus alternating use and charging. The transducer is much lighter than a battery.

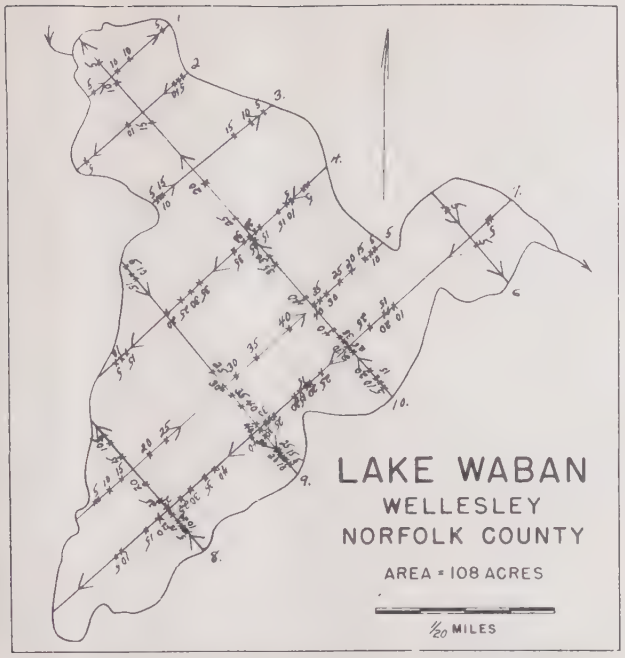
USING THE ECHO SOUNDER

Field Problems

In actual use under Massachusetts conditions, one man (the junior author) transported and handled the equipment (including loading and unloading the boat with sounder mounted in place), operated the boat, and recorded data. The boat was transported on a standard two-wheel boat trailer. For loading and unloading, the "fish" was unclamped and placed inside the boat, which was floated on or off the trailer backed under water. If the ground was soft or the slope gradual, a suitable length of manila rope attached to the truck was used to pull boat and trailer from the water. In practice, an average of three ponds per day could be sounded, including movements between ponds.

The authors found the echo sounder amazingly rugged; they never used the spare-parts kit while sounding more than 100 ponds in a couple months. The operators hit rocks at full speed, besides jolting over many rough roads with the sounder in its boat in the trailer, without harm to the sounder. Frequent adjustment of one electrical contact (the keying contact) was necessary initially, but this was a matter of "breaking in." After a few weeks of constant use, this necessity virtually disappeared.

A little experience was needed at reading the dial, particularly in shallow water (less than 15 feet or so), but this was soon acquired. Frequent checks with a sounding chain revealed no errors at any time after familiarization. This was also largely true of its use over flocculent muddy bottoms. In such instances the band of light indicating the dial reading became very broad and occasionally wandered slightly or "searched." The leading edge of such a band was generally



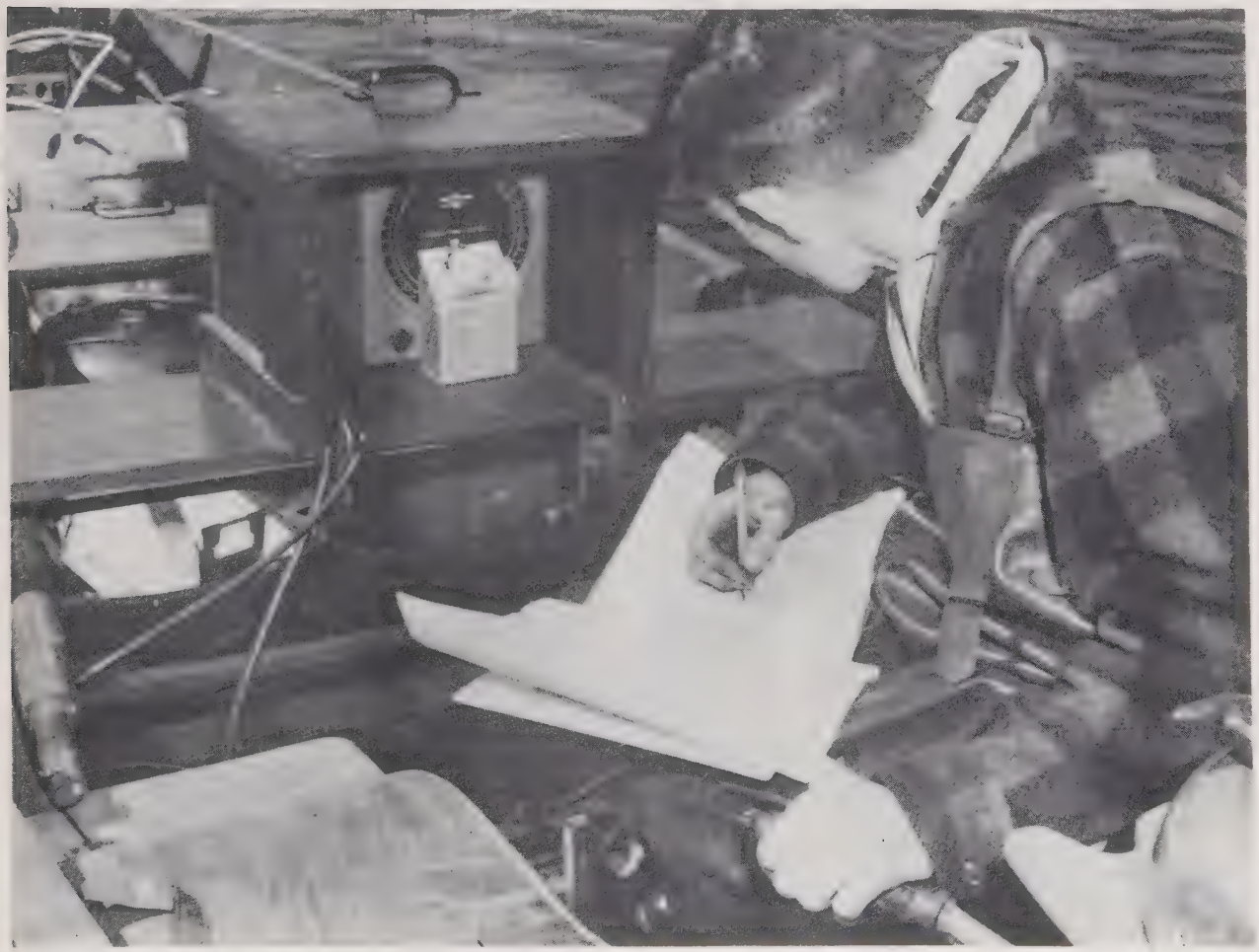
determined to coincide with the upper surface of the muddy layer. "Searching" was also experienced in a few ponds where the rooted aquatic vegetation was extremely dense and luxuriant. In such cases, however, reflections of sound from the actual bottom also occurred. Occasional checks with a sounding chain served to confirm readings in doubtful cases.

Acquiring the Data

Actual recording of the data was a simple process. A data sheet was evolved (figure 2) on which time was listed in double columns of 5-second intervals totaling 9 minutes.

FIGURE 3.--Map showing transects and intersections of contours.

FIGURE 4.--Indicator dial and stop watch mounted for determination of time of passage between contours.



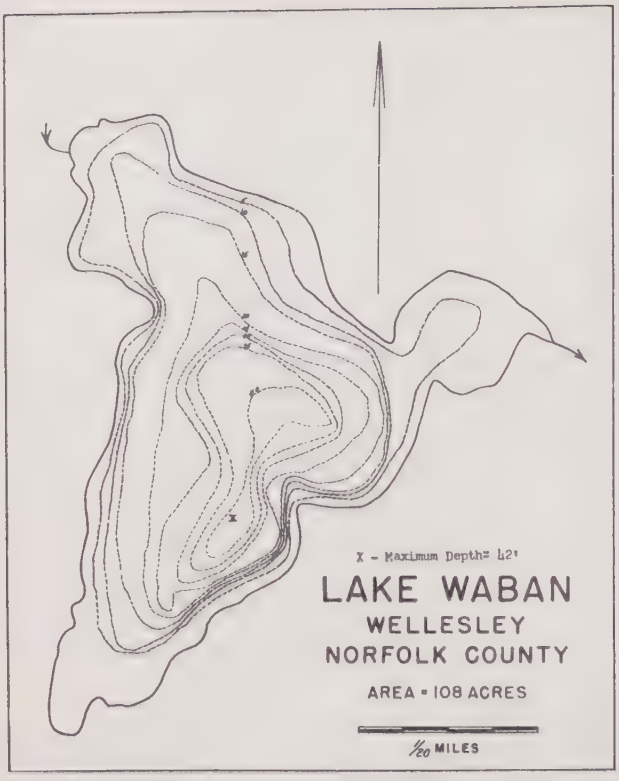


FIGURE 5.--Contour map prepared from echo-sounding data resulting from 2½ hours of field and laboratory work.

This was mimeographed on both sides of the sheet, which thereby provided four double columns on each side, one for each transect. Spaces were provided to record the distances from shore at start and finish of each transect passage. This was used in combination with an outline map on which several transects were plotted on the site (figure 3), carefully oriented with outstanding landmarks on the shore or skyline. The number of transects selected averaged 12 per pond but ranged from 5 to 63, depending on the judgment of the operator with respect to increasing experience and to shoreline and bottom irregularities.

All "runs" (passages along selected transects) were begun as close to shore as possible and in water less than 5 feet in depth. The distance from shore at start and finish was estimated visually (at 12 feet per boat-length) up to a distance no greater than three boat-lengths. Experience soon showed that estimates beyond this distance were likely to be erroneous. Beyond three boat-lengths, the position at start or finish was plotted on the map to minimize field error. The operator, properly oriented with the plotted transect, then immediately began his run at full speed of the 5-horsepower outboard motor employed, or at three-quarter speed or even half speed if the distance were short. The run was terminated with no preparatory decrease in the speed by cutting back from the course at an obtuse angle before throttling down. Thus the element of excitement was not entirely lacking from the daily routine.

During a run the operator maintained a properly oriented course at a constant speed and watched the flashing dial for the depth report when each successive 5-foot contour was crossed and reported on the dial. This depth was noted on the data sheet opposite the corresponding time in minutes and seconds required to reach this contour. A stop watch was mounted as shown in figure 4 to permit simultaneous awareness of time and depth. Total time for the run was indicated by a line drawn across the time data column at the appropriate place, and the maximum depth was recorded from memory for each run. The time columns for successive runs were numbered to correspond with numbered transects plotted on the outline maps.

The Final Map

A satisfactory contour map was then constructed in the base laboratory. Since with a constant speed of travel time is proportional to distance, the points on each transect where successive contours crossed the course of travel could be plotted readily by simple proportion. An hour's calculations served to establish these points on the outline. When these points had been connected with smooth curves, a fairly accurate contour map resulted. Any number of good copies can be traced from the master map. Such a map is shown in figure 5.

LITERATURE CITED

Burrows, C. R.
1949. An echo sounder for small boats. Prog. Fish-Cult. 11 (4): 199-201.

The author reports that since the completion of this article a new lightweight echo sounder operating from a 6-volt power supply and featuring a permanent record on continuous rolls of graph paper has appeared on the market. He believes, however, that this recording scale should be at least doubled for optimum results in fresh-water work.--The EDITORS.

PROPAGATION OF LARGEMOUTH BLACK BASS AND BLUEGILL SUNFISH IN FEDERAL HATCHERIES OF THE SOUTHEAST

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A REVIEW OF OUR FISH PRODUCTION program appeared several years ago (Blosz 1948). Since that article was written, many additional tests have been run at the various hatcheries of the Fish and Wildlife Service in the Southeast to determine methods of improving our production program. We are still evaluating data, and as yet our program is far from perfect. Some of these tests, however, indicate methods by which production can be greatly increased. The better to evaluate our present program and the goal which we hope to achieve, it might be well to review production for the past 6 years. Production figures for these years include all warm-water fish produced but deal primarily with largemouth black bass and bluegill sunfish:

Year	Total Production
1945	12,050,000
1946	12,570,000
1947	24,580,000
1948	25,660,000
1949	29,300,000
1950	29,950,000

Production figures for 1951 have not yet been assembled but should equal those for 1950. The above figures represent the approximate number of fish required each year to meet our farm-pond stocking program.

In the belief that the information may be of interest, some details of our hatchery operations are given here.

Southeast, as used here, refers to the States of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia, which are administered as Region 4 of the U. S. Fish and Wildlife Service.--The EDITORS.

In considering region-wide operations, it should be remembered that widely different conditions exist at the various hatcheries. For example, the pond water supply at one station may have a pH well on the acid side and be low in total carbonates, but the water at another hatchery may have a relatively high pH and be rich in total carbonates. At some of the stations, the ponds are well constructed and lose very little water by seepage or otherwise; again, we have hatcheries where there is a great amount of seepage and water loss combined with poorly constructed ponds. Regardless of local conditions, however, efforts are made to observe and follow certain basic principles.

As the waters stocked consist primarily of new farm ponds, one of our objectives has been to produce the smallest bass and bluegills which can be safely delivered to these ponds and give the desired results. Bass 1 inch in length and weighing approximately 1 pound per thousand handle well and are considered ideal. Bluegills weighing 10 ounces per thousand are considered satisfactory, provided that they are delivered late in the summer or early in the fall. Early delivery of bluegills of this size permits additional growth to be made before cold weather. As the season progresses, larger bluegills are needed in order to stock the farm ponds properly.

PRODUCTION OF LARGEMOUTH BLACK BASS

Brood Bass Holding Ponds

A prerequisite for successful bass production is brood stock of good quality. The fish must be properly fed and reasonably free of parasites. Several years ago the practice of hand feeding our adult bass was discontinued because of the expense involved. To replace this hand feeding, our project leaders have been instructed to set up brood bass holding

ponds early in the spring. These ponds are fertilized and are stocked with 100 adult bluegills per acre. By the time the adult bass have spawned and have been placed in the previously prepared holding ponds, young bluegills are available for the bass. These young bluegills also tend to eliminate any young bass that may hatch during the remaining part of the year. In order to eliminate rooted vegetation, the bass holding ponds are fertilized sufficiently to produce and maintain a good bloom. Where the quality of the water and pond construction normally permits high fish production, an acre pond prepared as indicated will support approximately 300 adult bass averaging 1-1/4 to 1-1/2 pounds each.

Every year, under normal hatchery conditions, loss of brood bass runs from 15 to 25 percent. In order to replenish the brood stock, the usual practice is to add 10 No. 1 bass per acre to each bluegill production pond. Survival is usually from seven to nine bass weighing 10 to 14 ounces each at the end of the season. These make satisfactory brood fish for the following year. Attempts are made to use bass of reasonably uniform size: bass weighing in excess of 3 pounds are usually discarded.

Brood Bass Spawning Ponds

The most important factors to be considered in the selection of spawning ponds are: reasonably constant water level, minimum depth of 2 to 2-1/2 feet, freedom from excessive wind action and muddy water, firm bottoms, and size ranging from 3/4 to 1-1/2 acres.

The spawning ponds are filled with water approximately a week before the adult bass are placed in the ponds. The bass are moved to the spawning ponds about 6 weeks prior to the normal time for taking the first good spawn of fry. This time is determined by checking station records from previous years. As a rule, where any appreciable number of bass is produced, the records will show a period of 3 to 5 days during which large numbers of fry are available in the spawning ponds. This period does not vary to any great extent from year to year.

The ponds are stocked with 80 bass per acre. These fish weigh 1-1/4 to 1-1/2 pounds each. Generally, no sexing is done, as we do not yet have enough evidence to indicate that sexing is a real contribution toward better production.

Schools of fry break up early in the season primarily because of a lack of food in the spawning pond. Therefore, all of these ponds receive some fertilization unless they are very fertile. The amount of fertilization is based upon the need to produce food and retard growth of rooted vegetation without producing a green bloom. The goal is to produce a brown stain as caused by the introduction of barnyard manure, various kinds of hay, or, quite often, cottonseed meal. The stain retards growth of rooted vegetation but permits the bass fry to be observed readily, whereas a green bloom would handicap the taking of fry.

When barnyard manure is used, it is placed in the ponds 4 weeks in advance of the usual time bass fry are ready for moving. The quantity must be sufficient to give the water a definite brown color. Usually a ton or more per acre is required.

Owing to the labor involved in securing barnyard manure and also to the fact that this material is not available in quantity, we often use a good-quality hay of high protein content, such as alfalfa. Usually a minimum of 500 pounds of this material per acre is required to color the water. The hay is placed in the ponds 5 to 6 weeks before the normal time for moving bass fry. A week later and thereafter at weekly intervals, two to three applications of an 8-8-0 or 8-8-2 inorganic fertilizer are broadcast over the hay at the rate of 100 pounds per acre per application.

When cottonseed meal is used instead of manure or hay, three weekly applications of the inorganic fertilizer are used at the rate of 100 pounds per acre per application. The fourth application of fertilizer consists of 135 to 150 pounds of cottonseed meal plus 45 to 50 pounds of 20-percent superphosphate. This fourth application is placed in the ponds about 3 weeks before normal fry-taking time. Usually a brown stain results from this application. Occasionally, however, a green bloom will develop; when this happens, it is an indication that fertilization has been too heavy. Each additional application of fertilizer, if any is required and as determined by the color of the water, consists of 50 pounds of an 8-8-0 or an 8-8-2 inorganic mix plus approximately 75 pounds of cottonseed meal plus approximately 25 pounds of 20-percent superphosphate. Fertilization is curtailed if a green bloom develops or appears to be developing.

If the bass are in good condition when placed in the ponds, sufficient natural food will be available and no hand feeding will be required. If deemed necessary, the bass are fed live minnows which are crippled so badly that they will die if not eaten by the bass. Relatively few minnows are ordinarily

A normal amount of rooted vegetation for a pond in which a fair-to-good bloom has been maintained.

required. If the minnows are not available, then occasionally it is necessary to resort to using beef hearts, melts, or similar foods.

Bass fry are taken from the spawning ponds to stock our nursery ponds or fry holding ponds and also for delivery direct to the applicants. Fry that are left in the brood ponds consist of broken schools of uneven-sized fish. Fertilization in the spawning ponds cannot be heavy because production of a green bloom prevents hatcherymen from locating the young bass. These factors mean poor fingerling production, and our brood bass spawning ponds are drained as soon as possible after the main spawn of fry has been taken. In any event, efforts are made to draw the ponds within 2 months after the main spawn. Early draining of these ponds allows them to be used for another crop of fish during the year. Usually the brood bass spawning ponds are drained during the latter part of May or the first of June, after the bluegill spawning season is well under way.

Taking and Handling Bass Fry

At the majority of our hatcheries, bass fry are moved from the spawning pond by means of bobbinet seines. By cruising over the water in a light boat, hatcherymen easily spot schools of fry during clear, quiet weather. If there are ripples on the pond, a commercial grade of fish oil is used to smooth the surface of the water. This oil is applied by using a regular pint oil can of the plunger type. The oil is applied on the windward side of the pond and soon spreads over the entire surface.

The general practice is to move the bass fry to the fry holding ponds when the fish are 1/2 to 5/8 inch in length. The number of fry transferred to the nursery or fry holding pond is determined by estimation. White enamel pans, about 12 inches in diameter and 4 to 5 inches in depth, are utilized to determine the number of fry. About 2 inches of water is placed in each pan. A counter or estimating pan is established by counting into a pan that number of fish which will give the pan the appearance of being lightly sprinkled with fish. A pan of the size indicated will accommodate about 1,000 fry as a sample for estimation. Fry are placed in the remaining pans by hand net until all the pans appear to have the same number of fish.

Equipment for taking bass fry.

Fry Holding Ponds

During the early spring, weather conditions are unpredictable. For this reason we are unable to plan our distribution trips well in advance and be assured of making delivery on schedule if we depend entirely upon securing the fish from the bass spawning ponds. As a safety factor, therefore, fry holding ponds are set up and heavily stocked with young bass. The stocking rate runs from 40,000 to 60,000 fry per acre. Efforts are made to secure reasonably even-sized fish, but some slight variation appears to cause little, if any, damage.

The factor which is most essential to good survival in our fry holding ponds is the presence of ample food in the ponds at the time the young fry are introduced. Therefore, the fertilization program for these ponds is given special attention. Seven weeks before bass fry are to be moved to the holding ponds, fertilization with the inorganic material begins. Our standard method is to apply three weekly applications of an 8-8-2 or similar inorganic fertilizer followed by a combination of organic and inorganic fertilizer. A fourth application is made approximately 3 weeks before the fry are introduced. This application of fertilizer consists of 135 to 150 pounds of cottonseed meal plus 45 to 50 pounds of superphosphate per acre. All later applications of fertilizer consist of 50 pounds of an 8-8-2 inorganic fertilizer plus 75 pounds of cottonseed meal plus 25 pounds of superphosphate per acre. Additional applications are made weekly until either a heavy bloom develops or the fry are placed in the ponds. No fertilizer is used after the fry are introduced.

Within 15 days after being placed in the holding ponds, the fry are large enough to handle well. Distribution trips are scheduled for definite delivery dates, the fry holding ponds are drained, and there is assurance that bass required for any particular trip will be available. When fry holding ponds are stocked at these heavy rates, our pond-draining schedule is set up so as to allow for draining such ponds within 25 to 28 days. If the ponds are not drained within this period, survival is usually poor. If the ponds have been properly fertilized, and if they are drained within the specified time limit, the survival usually runs from 70 to 80 percent, with the fish weighing from 12 to 20 ounces per thousand.

PRODUCTION OF BLUEGILL SUNFISH

Adult Bluegill Holding Ponds

We consider the care, handling, and replacement of brood stock equally as important in bluegill propagation as in bass propagation. The bluegill sunfish, however, present fewer problems. Feeding is a simple matter, and replacement is readily accomplished.

At the majority of our hatcheries, the year's production program requires that many of the ponds be used to produce a crop of bass early in the spring and a crop of bluegills later. At the close of the bluegill season, therefore, the adult fish are placed in holding ponds until time to place them in the production ponds after the bass season. The draining of the bluegill production ponds begins during the late summer and continues through the winter. As the ponds are drained, the adults are assembled in ponds previously set aside for holding these fish. The ponds are fertilized to produce and to maintain a bloom. Well-fertilized holding ponds carry approximately 1,000 6- to 8-ounce fish without supplementary feeding. If a good bloom cannot be maintained, the number of fish per acre is reduced or supplementary feeding is given. When feeding is required, soybean meal has produced excellent results. This material is fed dry and at the rate of 5 to 10 pounds per acre per day. Some of the hatcheries are using meat products but in less quantity per day.

Replacement of Brood Stock

During the past few years sufficient evidence has been accumulated to indicate that parasites in the bluegills may cause serious trouble. In order to reduce to a minimum the damage by parasites, the brood stock is replaced every 2 years where pond operations permit. This replacement is accomplished by using bluegill fingerlings as brood stock in production ponds. The fingerlings are stocked at approximately two and one-half times the normal adult stocking rate and are placed in the production ponds during the fall. The ponds are kept well fertilized throughout the winter and following spring. Ponds stocked and handled in this manner give good fingerling production and at the same time produce brood stock. For each acre so stocked, 2 acres can be stocked the following year with 2-year-old fish at the standard stocking rate. Where one-third of the bluegill ponds are handled in this way each year, brood stock can be replaced every 2 years.

Bluegill Production Ponds

At all the hatcheries in this Region, two crops of fish per pond can be produced each year. An early crop of bass can be followed by one or two crops of bluegills. For a few years we considered the production of two crops of bluegills desirable for those ponds not required for bass production. For such production it was necessary to drain and restock ponds and distribute bluegills to farm ponds in July. Because planting of bluegills in farm ponds this early in the season was very questionable, this practice has been discontinued. Our present program calls for the production of two crops of fish per pond only when bass are produced as the first crop.

We have been stocking our bluegill production ponds as follows:

1. Stocking of 2-inch fingerling bluegills in late fall at two and one-half times the adult stocking rate.
2. Stocking of adult fish in early spring.
3. Stocking of adult fish in late spring and early summer.

The first method is used in order to produce new brood stock while producing a crop of fingerlings. Fingerling production in these ponds is usually slightly less than in ponds stocked with adult fish. The second method has been used when it appeared that station operations would benefit. It is a questionable method, and results are not so consistently good as when ponds are stocked later in the year. The third method is used in the majority of our ponds and usually after a crop of bass has been produced. This stocking is ordinarily done during the latter part of May or early in June.

In determining the number of adult bluegills to use, we are guided somewhat by the pounds of production expected from the ponds to be stocked and by the size of fingerlings we want to produce. In soft water, production in pounds is low; in hard water, production is high. Our production goal has been to produce large numbers of bluegill fingerlings weighing 10 ounces or more per thousand by about August 15. At some hatcheries we find that 100 adult bluegills per acre are satisfactory, while at others 60 per acre are too many. This difference is due to the difference in potential production capacity at the various hatcheries.

The adult fish are generally not sexed at the time they are placed in the production ponds, as we have not enough data to evaluate properly this phase of fish culture. Assuming that the brood fish are 50 percent females and 50 percent males, we find that fingerling production per pair or per female averages 2,500 to 3,000 when the adults weigh 6 to 8 ounces each.

When fingerling bluegills are used for brood fish and the ponds are stocked during the fall, inorganic fertilizer is generally used at the rate of 100 pounds per acre every 7 to 10 days until a bloom develops and thereafter as required to maintain a bloom until the ponds are drained.

For those ponds which are stocked early in the spring with adult bluegills, fertilization is started 6 to 7 weeks prior to the normal time for the young bluegills to be swimming and feeding. Fertilization is the same as for the bass fry holding ponds. If we fail to develop a plentiful supply of food in the ponds by the time the young bluegills are ready to feed, survival is poor and the young bluegills are very uneven in size when the ponds are drained.

In those ponds which produce a crop of bass and are then used to produce a crop of bluegills, we find that there is some carry-over of fertility and organic matter. The ponds, in effect, are partially fertilized at the time of filling for bluegill production. Food organisms apparently carry over and then develop rapidly once the ponds are filled. As the organic matter decays rapidly, caution is exercised in stocking these ponds with adult bluegills. This rapid decay endangers the fish by reducing the oxygen supply. For

such ponds, the initial fertilization generally consists of inorganic fertilizer for one or two applications at weekly intervals and at the rate of 50 pounds per acre. After a bloom develops, a combination of inorganic and organic fertilizer is utilized unless special conditions at the station prevent use of organic material.

To give production figures without detailed data leading to the particular production, seems to be of little value. The reason for this is the wide range in production, which varies from a very few pounds and numbers per acre to high poundage and high numbers. It is sufficient to say that we do not consider production good if it amounts to less than approximately 120,000 bluegills (160 pounds) per acre. Our highest production has amounted to approximately 350,000 fingerlings (about 700 pounds) per acre.

This highest production occurred where special production programs were being tested and the quality of the hatchery water was considered only average. This method of producing fingerling bluegills has been tested sufficiently to cause us to believe that it can eventually be made a standard production procedure at the majority of hatcheries. The procedure is basically that of producing a heavy crop of rooted vegetation. This vegetation is then converted into microscopic plants either by heavy fertilization or by treatment with chemicals combined with fertilization.

Inorganic fertilizer is used early in the spring to produce a crop of rooted vegetation by the end of the first one-third to one-half of the season. Vegetation consists of fine-leafed Potamogeton, Najas, Chara, or similar plants. After the vegetation has become well developed, enough of it is treated with sodium arsenite or copper sulphate so that a light bloom results from release of plant nutrients. One-fifth to one-fourth of the pond area is usually enough to treat initially. The light bloom which results from the treatment slowly shades out the remaining vegetation and thus creates ideal conditions for fish production. When the bloom fails to develop as rapidly as is desired, inorganic fertilizer is used to speed up the process of decay. This method of fertilization is dangerous and requires a great amount of judgment on the part of the fish-culturist. If and when fish-culturists learn how to use this method of production regularly without loss of fish, our production will undoubtedly be more than doubled.

USE OF CHEMICALS IN HATCHERY PONDS

Sodium arsenite and copper sulphate have been used successfully in treating pond vegetation. Both chemicals have advantages and disadvantages. The sodium arsenite is very caustic and is considered difficult to handle. It does not adversely affect the fish or their food to the same extent that copper sulphate does. Copper sulphate handles easily, but its use endangers the fish and their food.

Sodium arsenite is used to treat plants such as Najas, Potamogeton, Ceratophyllum, Myriophyllum, Anacharis, and others. We prefer using the commercially prepared liquid sodium arsenite because it usually does not cause so much trouble with spraying equipment as does a similar solution made from the dry sodium arsenite. The liquid, as normally purchased from commercial dealers, is mixed half-and-half with water and is applied at the rate of 8 p.p.m. for the area treated. When applied in this dilution, the material sinks rapidly and does not spread over an area appreciably larger than that treated.

Copper sulphate is used primarily to treat Chara, filamentous algae, and, at some stations, Najas. If applied as a solution and sprayed over the entire pond area, a maximum of 1 p.p.m. is used. At this strength and applied as a solution, the chemical is used for the purpose of treating filamentous algae. Crystals are used to spot-treat filamentous algae, Chara, and Najas. Usually the crystals are applied at the rate of 3 pounds per thousand square feet of area treated. In some waters and particularly when treating summer algae, crystals are used at 6 to 8 pounds per thousand square feet. Results vary from one hatchery to another, and the reasons for these inconsistencies have not yet been fully determined. Hard water ordinarily permits the use of a higher concentration of copper sulphate without damage to fish life than does soft water. In some hard-water ponds, the crystals have been used at rates as high as 6 to 8 p.p.m. without causing damage to fish. Similar treatments in soft-water ponds have caused extensive fish losses.

Sodium arsenite will not necessarily produce the same results at any two stations, even though the chemical is applied on the same kind of vegetation. At every station it is necessary to run tests to determine the effectiveness of the chemicals at that particular location.

LITERATURE CITED

Blosz, John.
1948. Fish production program, 1947, in the Southeast. Prog. Fish-Cult. 10 (2): 84-87.

BIOTIN, PANTOTHENIC ACID, AND BROWN TROUT

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THE CORTLAND LABORATORY has previously reported that the addition of either beef liver or dried brewer's yeast to the diet of brown trout resulted in an accelerated growth rate and a reduction in the mortality caused by "blue-slime" disease (Phillips et al. 1949, 1950). This earlier work indicated that there was a correlation between blue-slime disease and the vitamin biotin. Such a correlation was noted between the dietary level of the vitamin and the amounts found in the livers of normal and diseased fish. That biotin was perhaps not the only factor involved, has been shown by the fact that these researchers have never been able to eradicate blue-slime: it has been possible only to hold the disease in check and prevent excessive losses of the trout.

That biotin is concerned directly with the growth of trout, was demonstrated at the Cortland Laboratory when the removal of biotin by means of the antivitamin avidin (found in egg white) resulted in practically no growth among three species of trout (Phillips et al. 1950).

The Wisconsin workers (McLaren et al. 1947) reported that biotin was an essential for the growth of rainbow trout.

Wolf stated (1951) that in his studies no need for the vitamin biotin had been demonstrated, and that lack of pantothenic acid resulted in blue-slime disease among rainbow trout. Wolf's studies consisted of feeding purified forms of the various vitamins to trout and measuring their response in terms of growth, mortality, and appearance of disease. No attempt was made to measure the level of the vitamin itself in the body of the fish.

In the summer of 1951, a series of experiments was designed in which brown trout were fed the standard, unfortified diet of the Cortland Hatchery. Other groups were fed the standard diet plus supplements of beef liver and various sources of yeast. At the end of 10 weeks, and again at the end of 18 weeks, samples of trout were removed from the troughs and killed, and their livers were analyzed for the two vitamins in question (biotin and pantothenic acid). These analyses were made by means of microbiological assays according to procedures previously described (Phillips et al. 1946, 1947). Attempts were then made to correlate the appearance of the blue-slime disease with the storage of either vitamin in the liver of the trout.

The experimental groups of fish were held in troughs supplied with water at an average temperature of 52° F. and were handled in accordance with the established procedure at this laboratory (Tunison et al. 1939). The experiments were continued for a 20-week period. All data were analyzed statistically by means of analysis of variance.

The composition of the diets is shown in table 1, and the results have been summarized in table 2.

The control lots (which received diets No. 1285 and No. 1286) showed a low biotin storage in their livers. The mortality among these fish was so great that they were a total loss by the end of the experimental period. The outbreak of blue-slime was one of the worst ever seen at this hatchery. The pantothenic acid content of the livers was equal to that of any of the other lots of fish, and no correlation could be found between the disease in question and this vitamin.

The addition of yeast No. 1 (diets No. 1287 and No. 1288) resulted in a marked reduction in the mortality among the fish and reduced the amount of blue-slime to such a degree that it was difficult to find typical examples. The level of pantothenic acid in the liver was unchanged although the biotin in the liver was almost double that of the controls by the end of the second series of analyses.

TABLE 1.--Diet composition (in percent) for brown trout experiments in which yeast or beef liver was fed as a supplement

Diet No.	Beef melts	Dry mix No. 6a (1/)	Yeast No. 1 (2/)	Yeast No. 2 (3/)	Yeast No. 3 (4/)	Beef liver	Fresh egg white
1285	50	50	-	-	-	-	-
1286	50	50	-	-	-	-	-
1287	50	45	5	-	-	-	-
1288	50	45	5	-	-	-	-
1289	50	45	-	5	-	-	-
1290	50	45	-	5	-	-	-
1291	50	45	-	-	5	-	-
1292	50	45	-	-	5	-	-
1293	30	50	-	-	-	20	-
1294	30	50	-	-	-	20	-
1295	30	42	-	-	-	20	8
1296	30	42	-	-	-	20	8

1/ Composed of fish meal, 48 parts; wheat middlings, 24 parts; cottonseed meal, 24 parts; salt, 4 parts.
2/ Type 50-B yeast, furnished by Standard Brands, Inc., New York City.
3/ Wood yeast, furnished by Lake States Yeast Corporation, Rhinelander, Wisconsin.
4/ Non-debittered food yeast, furnished by Yeast Products Corporation, New York City.

Two other yeast supplements also increased the biotin level of the liver but to a less degree than yeast No. 1, although yeast No. 2 was quite effective at the end of 10 weeks. The mortality among the fish receiving these yeasts was greatly reduced in comparison to the mortality among the controls. Again there was no correlation between liver pantothenic acid and blue-slime disease or mortality.

The addition of 20 percent beef liver (in No. 1293 and No. 1294) produced results equal to those found with yeast No. 1. This again supports the contention that 5 percent yeast is equivalent to 20 percent beef liver so far as the control of this disease is concerned. Once more no difference could be found in the storage of pantothenic acid, even though there was a definite reduction in the loss of the fish.

Fresh egg white was received by the groups fed the diets No. 1295 and No. 1296, which also contained 20 percent beef liver. This use of fresh egg white was an attempt to bind the biotin and measure the effect of its removal from the diet. The analyses showed that such a tie-up did occur (as reflected by the biotin in the liver of the trout), but apparently there was insufficient egg white to remove enough of the biotin to affect either the loss of the fish or their growth rate. Previous experiments with dried egg white have shown that a very efficient job can be done on reducing the growth rate of trout by this method. Probably the failure of fresh egg white to duplicate previous results in this laboratory can best be explained by the level of biotin in the liver of the fish. Although the fresh egg white did reduce the liver biotin in comparison to that of the supplement-fed fish, the fresh egg white did not reduce the biotin to the levels of the controls. It is believed, therefore, that the fresh egg white resulted in biotin content near the critical level but not low enough to cause excessive losses and a reduced rate of growth.

The actual values for the liver levels of biotin agree closely with our previous analytical results, and again there is strong indication of a correlation between biotin and blue-slime disease. No such correlation was found for pantothenic acid.

It should be noted that there was a lower storage of pantothenic acid in the liver of the fish in all groups at the time of the second series of analyses. These results agree with previous reports (Phillips et al. 1946), in which it was stated that larger and older fish had less of this vitamin in their livers even when fed diets extremely high in pantothenic acid.

It is again suggested that either dried brewer's yeast or beef liver may be used in controlling blue-slime disease among brown trout. Previous experiments (Phillips et al. 1949) have shown similar results with both brook and rainbow trout, especially when cod-liver oil is used in the diet. As biotin is primarily a growth factor, the use of these supplements is warranted during periods of rapid growth due to either fish size, water temperature, or diet composition.

TABLE 2.--Vitamin content and growth data of brown trout fed supplements of yeast or beef liver

Diet No.	Average weight at end, grams[1/]	Total percent gain in weight	Average 2-week mortality percent	Millimicrograms biotin per gram of fish liver	Micrograms pantothenic acid per gram of fish liver
			First series of analyses		
1285	-	-	-	505	16
1286	-	-	-	513	14
1287	-	-	-	886	15
1288	-	-	-	1,102	13
1289	-	-	-	982	13
1290	-	-	-	1,102	14
1291	-	-	-	742	18
1292	-	-	-	650	15
1293	-	-	-	966	13
1294	-	-	-	955	14
1295	-	-	-	551	17
1296	-	-	-	685	14
			Second series of analyses		
1285	(total loss at end)		21.9	525	13
1286	(total loss at end)		28.7	525	14
1287	4.76	890	4.9	1,041	12
1288	4.35	804	3.8	1,018	13
1289	4.80	899	5.9	745	11
1290	4.39	814	6.0	735	10
1291	5.15	970	8.7	691	11
1292	7.90	1,600	10.5	775	13
1293	5.38	1,019	6.2	1,180	15
1294	5.95	1,135	6.2	1,244	13
1295	5.53	1,049	5.8	640	16
1296	5.45	1,033	5.5	651	14

[1/] Average weight at start, 0.481 grams.

These data indicate a definite difference in the various types of yeast when used to prevent excessive losses due to blue-slime disease. It may well be that those yeasts which produce low liver storage would be far more efficient at higher dietary levels, and such should be tried. Unfortunately, that yeast producing the best results is quite expensive in comparison to the other brands; but in most instances it is still cheaper at a 5-percent level of the diet than beef liver at a 20-percent level. It is felt that although the other yeasts (No. 2 and No. 3) did reduce the losses of the fish, the liver storage shows them to be on the borderline. This may well explain some of the erratic results reported from the field.

It should be mentioned that the dried egg white used in the experiments at this laboratory was prepared extremely carefully by drying under vacuum at very low temperatures. This resulted in a product that underwent a minimum number of changes--a product in which the avidin, or antivitamin of biotin, was apparently unharmed. Under ordinary circumstances, the cooking of eggs destroys the avidin present and eggs that have been cooked thoroughly will not result in a deficiency of biotin. It is possible that the use of fresh eggs as such, or the mere slight coagulation (or coddling) of eggs, will result in a biotin deficiency; such products should be used with caution. Dried eggs that appear on the market or that are occasionally available through Government surplus agencies should work satisfactorily because these eggs are dried at relatively high heat. Again, however, use of these eggs should be made with caution and a careful check should be maintained for the first signs of losses.

One last remark should be made in regard to the use of beef liver or yeast in the diet

of brook trout. Experiments have shown that cod-liver oil in the diet of brook trout will result in an accelerated growth rate of the fish. However, the mortality is also increased. The addition of either yeast or beef liver will reduce the mortality to a very low level and result in better and more efficient feeding practices for the hatchery. It does appear that any factor affecting the growth rate of trout plays a role in increasing the losses of the fish when the standard diet of the Cortland Hatchery is employed. Proper fortification of the diet can overcome these difficulties.

For excellent cooperation in the care of the experimental fish, appreciation is expressed to Robert A. Chadwick.

LITERATURE CITED

McLaren, B. A.; Keller, Elizabeth; O'Donnell, D. J.; and Elvehjem, C. A.
1947. The nutrition of rainbow trout. I. Studies of vitamin requirements. Arch. Biochem. 15 (2): 169-178.

Phillips, A. M.; Brockway, D. R.; Rodgers, E. O.; Sullivan, M. W.; Cook, Blendon; and Chipman, J. R.
1946. The nutrition of trout. Cortland Hatchery Report 15. N. Y. Cons. Dept. Fish. Res. Bull. 9, 21 pp.

------ Brockway, D. R.; Rodgers, E. O.; Robertson, R. L.; Goodell, Herbert; Thompson, J. A.; and Willoughby, Harvey.
1947. The nutrition of trout. Cortland Hatchery Report 16. N. Y. Cons. Dept. Fish. Res. Bull. 10, 35 pp.

------ Brockway, D. R.; Bryant, Maurice; Rodgers, E. O.; and Maxwell, J. M.
1949. The nutrition of trout. Cortland Hatchery Report No. 18 for the year 1949. N. Y. Cons. Dept. Fish. Res. Bull. 13, 30 pp.

------ Brockway, D. R.; Kolb, A. J. J.; and Maxwell, J. M.
1950. The nutrition of trout. Cortland Hatchery Report No. 19 for the year 1950. N. Y. Cons. Dept. Fish. Res. Bull. 14, 24 pp.

Tunison, A. V.; Phillips, A. M.; Rodgers, E. O.; Mitchell, C. R.; and McCay, C. M.
1939. The nutrition of trout. Cortland Hatchery Report No. 8. N. Y. Cons. Dept., 33 pp.

Wolf, L. E.
1951. Diet experiments with trout. Prog. Fish-Cult. 13 (1): 17-24.

ARGULUS OUTBREAKS IN MINNESOTA LAKES

HEAVY INFESTATIONS of Argulus, noted in connection with instances of extensive mortality among walleye pike and bullheads in Minnesota lakes within the last few years, have been reported by Robert E. Schumacher of the Fisheries Research Unit, Bureau of Fisheries, Minnesota Department of Conservation.

In August 1951, the Fisheries Research Unit was called upon to investigate the occurrence of a fish kill in Clear Lake, a small shallow lake in Jackson County. Examination of the dead fish, which consisted of walleye pike (Stizostedion vitreum vitreum) and bullheads (Ameiurus sp.), revealed the presence of the parasitic Argulus appendiculosus in numbers greater than 50 copepods per walleye examined. Chemical analysis of the water indicated that a large amount of algal decomposition may have taken place and lowered the oxygen levels in the lake. It is pointed out by Mr. Schumacher that this condition may have contributed to the mortality among the fish that were infested with Argulus.

A similar outbreak of this fish louse had been observed in Collingwood Lake, in central Minnesota, in 1947 and 1948. The mortality among walleye pike in this lake was extremely heavy, and investigation revealed that Argulus appendiculosus occurred in numbers exceeding 100 copepods per walleye examined. Here, too, many of the bullheads that were infested with Argulus died.

Mr. Schumacher concludes that although heavy infestations of Argulus appendiculosus are rare in Minnesota lakes, the outbreaks that do occur apparently can cause considerable mortality among both walleye pike and bullheads.

SURVIVAL AND GROWTH OF STOCKED LAKE TROUT YEARLINGS FROM SENECA AND RAQUETTE LAKE BREEDERS

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RAQUETTE LAKE, in the Adirondack Mountains in Hamilton County, New York, has an area of 5,395 acres. The maximum depth is 96 feet. As in other Adirondack waters, the lake trout spawn over rocky bottoms, usually in water less than 10 feet deep. The height of spawning occurs between October 18 and October 23.

Seneca Lake, which has an area of 42,688 acres and a maximum depth of 618 feet, is the largest and deepest of New York's Finger Lakes. As far as is known, the trout spawn at depths of 150 to 300 feet. Spawning activity in this lake reaches a peak about October 10.

This difference in spawning habits has prompted the suggestion that the lake trout in Seneca Lake may be a race different from that found in many Adirondack lakes. Further evidence of differences between lake trout from these two sources has been reported by Haskell (1952). Haskell found that under hatchery conditions lake trout fingerlings from Seneca breeders had a more rapid growth rate than fingerlings from breeders from two Adirondack lakes (Raquette and Saranac) when adjustments were made for age and water temperatures. The purpose of the present study was to compare the survival and growth of lake trout yearlings of Seneca and Raquette origin when stocked in Raquette Lake.

One thousand yearlings from Seneca and 1,000 yearlings from Raquette breeders were stocked in Raquette Lake in May 1942. These yearlings had been raised from the fingerlings used in Haskell's experiment. The fish were marked by the removal of the left ventral fin on the Raquettes and the right ventral fin on the Senecas. The average length of the fish at the time of planting was 5.75 inches for the Senecas and 5.0 inches for the Raquettes.

Survival

The number of experimental fish recovered by netting is shown in table 1. All netting was done with trap nets. During spawn-taking operations in 1946 and 1947, 36 Raquettes and 2 Senecas were recovered. The trout recovered in 1946 and 1947 were tagged so that they could be identified if taken again. Test netting for three nights in October 1951 yielded 13 Raquettes and 1 Seneca. The one Seneca and two of the Raquettes netted in 1951 were tagged fish which had been taken previously.[1/] Eliminating repeats, the returns from netting were 47 Raquettes and 2 Senecas.

With the inclusion of two Raquettes that were taken by angling in 1951, the total known survivals were 49 Raquettes and 2 Senecas.

The recovery data suggest that the survival of the Raquette yearlings was considerably better than that of the Senecas. There is a possibility that the survival data were biased in favor of the Raquette trout. All but two of the fish recovered were taken by netting in shallow water during the spawning season. Since the Seneca trout were from stock that spawn in deep water, they may not have been in the shallow-water areas even though present in the lake; but whether or not this behavior difference existed has not been established. Limited gill netting in deep water during the spawning seasons of 1947 and 1951 yielded only one immature lake trout. The area of the lake sampled by gill nets was too small, however, to furnish much information on the presence or absence of Senecas in deep water. The capture of two Senecas from the spawning beds does indicate

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1/ The exact location from which the tagged trout were taken in 1946 and 1947 is not known, so that it is impossible to determine whether the recaptures of 1951 were taken in the same location. The netting operations in 1946 and 1947 pretty well covered the known, much-used spawning areas of the lake. The 1951 netting was a small sample from two of the same beds. Most of the spawning beds which have been netted are located fairly close together.

TABLE 1.--Recoveries, by netting, from 1,000 Seneca and 1,000 Raquette lake trout yearlings stocked in Raquette Lake in 1942

Year	Total number trout caught	Raquette		Seneca	
		Male	Female	Male	Female
1946	2,505	5	0	1	0
1947	1,056	25	6	0	1
1951	599	1/12	1	1/1	0

1/Two of the Raquette males and the one Seneca male recovered in 1951 were tagged trout which had been recaptured once before, in either 1946 or 1947. Omitting repeats, the total returns from netting were 47 Raquettes and 2 Senecas.

that lake trout of Seneca origin do spawn in shallow water in Raquette Lake at least to some extent.

Growth

Not enough Senecas were recovered to permit comparison of their growth with that of the Raquettes. The average length and weight of the Raquettes recovered are shown in table 2. Data are available on two Senecas: the male taken in 1946 was 18.5 inches long and weighed 31 ounces; the female taken in 1947 was 17.5 inches long and weighed 30 ounces.

A comparison of the average lengths and weights of stocked trout of Raquette origin with average lengths and weights of unmarked trout of the same age is shown in table 3. The unmarked trout presumably consist of fish from two sources, natural reproduction and fingerling stocking. Inspection of the data reveals that in each instance the unmarked fish are slightly larger than the stocked fish of comparable age. An analysis of variance shows that in both years the male unmarked trout are significantly longer and heavier than male stocked trout. On the basis of the small amount of information available, the difference in average lengths of the females was not significant and the difference in weight was significant. The length and weight data suggest that the growth rate of trout stocked as yearlings may be somewhat slower, at least during the first 7 years of their life, than that of trout from natural reproduction and fingerling stocking.

Fin Regeneration

The fin-clipping operation here was more thorough than is customary. The

TABLE 2.--Average lengths and weights of lake trout recaptured from 1,000 Raquette yearlings stocked in Raquette Lake in 1942

Year	Males			Females		
	No.	Length	Weight	No.	Length	Weight
		Inches	Ounces		Inches	Ounces
1946	5	16.5	23.0	0	-	-
1947	24	17.8	27.5	6	18.7	33.5
1951	12	21.5	55.6	1	20.2	58.0

ventral fins were removed by means of scissors in the fall of 1941, when the fish were fingerlings. All the fish were looked over in the spring of 1942 prior to planting, and any fins showing regeneration were reclipped. There was no regeneration of the ventral fins of the six trout recovered in 1946. Of the 32 fish recovered in 1947, 28 showed no regeneration and 4 showed about 10 percent regeneration of ventral fins. Among the 14 recoveries in 1951, regeneration did not appear in 8 fish but appeared to the extent of 10 percent in 1 fish, 25 percent in 4 fish, and 75 percent in 1 fish. These observations indicate that removal of a ventral fin is a satisfactory means of marking lake trout for long-term survival studies.

Information is available on regeneration of the ventral fins of three trout which were recaptured twice. Two trout which were first taken in 1946 and recaptured in 1951 showed no regeneration of the ventral fins at either time. A trout taken in 1947 was recorded as having no regeneration of the left ventral fin. When this trout was recaptured in 1951, it was estimated that the ventral fin showed 10 percent regeneration. It is suspected that the difference reported is due to variation

TABLE 3.--Comparison of average lengths and weights of stocked lake trout of Raquette Lake origin with unmarked trout of the same age

Year of capture	Age	Stocked			Unmarked		
		No.	Length	Weight	No.	Length	Weight
			Inches	Ounces		Inches	Ounces
				Males			
1946	5	5	16.5	23.0	19	18.0	28.6
1947	6	24	17.8	27.5	21	18.8	32.3
				Females			
1947	6	6	18.7	1/33.5	32	19.3	2/38.3

1/The 6 stocked females were weighed before they had spawned.

2/The 32 unmarked females were spent when weighed. The average weight of unmarked females has been adjusted by adding 4 ounces (which has been found to be the average weight of the egg complement for trout of this size in Raquette Lake) in order to compare it with average weight of the stocked females.

in the estimates made by two individuals rather than to actual growth of the fin between 1947 and 1951.

Conclusions

1. The survival of yearling lake trout from Raquette Lake breeders appeared to be considerably better than the survival of the yearlings from Seneca Lake breeders, when stocked in Raquette Lake. The inference is that there may be racial differences between the lake trout in Seneca and Raquette Lakes that affect survival. The possibility that racial differences exist has been suggested also by observed differences in spawning habits and the growth rate of young in the hatcheries. The validity of the observed differences in survival depends on the condition that trout of Seneca Lake stock spawn in the same areas in Raquette Lake as trout of Raquette Lake stock, as survival data are based on net catches of spawning fish. This assumption has not been proved. Studies now in progress in three Adirondack lakes are designed to compare the survival of lake trout from breeders from Seneca and Upper Saranac Lake, the latter an Adirondack lake.

2. Length and weight data suggest that the growth rate of lake trout of Raquette Lake origin stocked as yearlings may be slower than the growth rate of trout from natural reproduction and fingerling stocking.

3. The removal of ventral fins is judged to provide a satisfactory means of marking yearling lake trout for long-term studies.

Literature Cited

Haskell, D. C.
1952. A comparison of the growth of lake trout fingerlings from eggs taken in Seneca, Saranac, and Raquette Lakes. Prog. Fish-Cult. 14 (1): 15-18.

A QUICKLY CHANGED BRUSH CLAMP

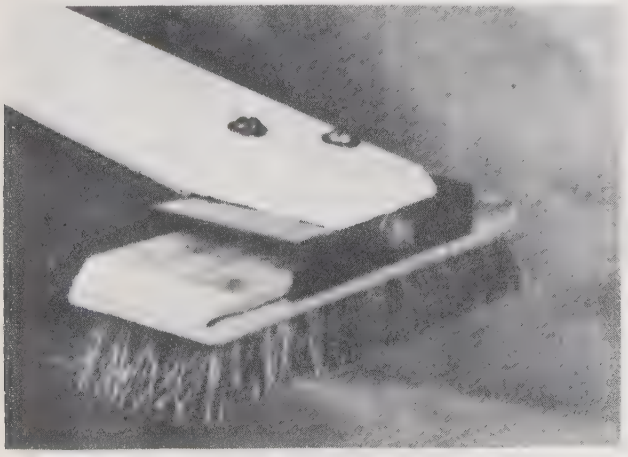
THE REPLACEMENT of brushes used in daily cleaning of pond screens has been made easier at the State fish hatchery at Oden, Michigan, through use of the brush clamp submitted by Reginald F. Sharkey.

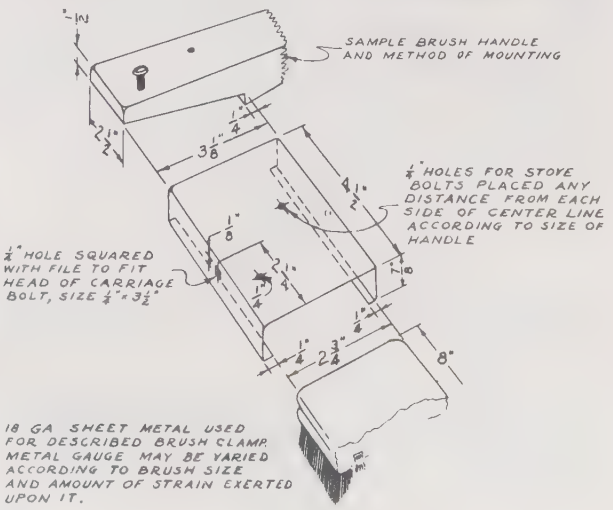
To change brushes, it is necessary only to loosen the nut on the pressure bolt, knock out the old brush, insert a new one, and tighten the nut.

The stove bolts holding the clamp to the brush handle should have washers at the head, and the undersurface of the clamp requires lock washers under the nuts. Bolts should be cut as close to the nuts as possible to allow clearance for insertion of the brush. The pressure bolt (carriage bolt), which controls the clamp jaws, should have a washer and lock washer under the nut.

Asphaltum applied to the clamp and nuts will keep the clamp rust-free and facilitate the removal and replacement of brushes.

If a brush has no grooves on the sides, these can be cut--the width of a table saw blade, slightly shallower than the clamp jaws.




SAMPLE BRUSH HANDLE AND METHOD OF MOUNTING
¼" HOLES FOR STOVE BOLTS PLACED ANY DISTANCE FROM EACH SIDE OF CENTER LINE ACCORDING TO SIZE OF HANDLE
¼" HOLE SQUARED WITH FILE TO FIT HEAD OF CARRIAGE BOLT, SIZE ¼" × 3½"
8"
18 GA SHEET METAL USED FOR DESCRIBED BRUSH CLAMP. METAL GAUGE MAY BE VARIED ACCORDING TO BRUSH SIZE AND AMOUNT OF STRAIN EXERTED UPON IT.

A Rapid Presumptive Test for Furunculosis in Fish

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THE CONVENTIONAL METHODS employed in the laboratory and field for the bacteriological diagnosis of furunculosis in fish consist of (1) inoculation of the surface of a trypticase-yeast extract agar slant with material taken either from a closed abscess or from the kidney of the diseased fish; (2) inoculation into a semisolid trypticase-yeast extract medium (0.1 to 0.3 percent agar); (3) incubation of the inoculated media at 22° C. for a suitable period of time.

This presumptive test for Bacterium salmonicida (the etiological agent of furunculosis) is considered to be positive if (1) a red-brown pigment develops in the agar slants after two or three days' incubation and (2) a spreading type of growth is absent along the line of inoculation in the semisolid agar usually within 24 hours (Gutsell and Snieszko 1948, 1949). Although this test is adequate, the rapidity with which one can report the "positive presumptive" for furunculosis is conditioned by the length of time necessary for the appearance of the characteristic red-brown pigmentation in the medium.

The present report concerns a rapid method by which one can make a positive presumptive diagnosis, a method which eliminates the necessity of waiting for the appearance of pigmentation. The procedure is presented without detail of experimental rationale because a more extended discussion will appear elsewhere (Griffin et al., in preparation).

METHODS

1. Prepare a 1-percent aqueous solution of paraphenylenediamine and store under refrigeration until used. The reagent is stable for at least 6 weeks.

2. Streak the surface of a slant of trypticase-yeast extract agar with suitable material taken from the fish which is suspect of furunculosis. Incubate the slant at 20° to 22° C. for 18 to 24 hours.

3. If growth is visible at the end of this time, "flood" the lower half of the slant with 0.5 milliliter of the test reagent (paraphenylenediamine) by means of a pipette. The reagent should be added directly to the surface of the colonies, and the tube should be rotated immediately for 2 to 3 seconds in such a manner as to allow complete contact of the reagent with the colonies on the lower half of the slanted surface.

4. Place the tube in an upright position in a test-tube rack and make observations based upon the following information.

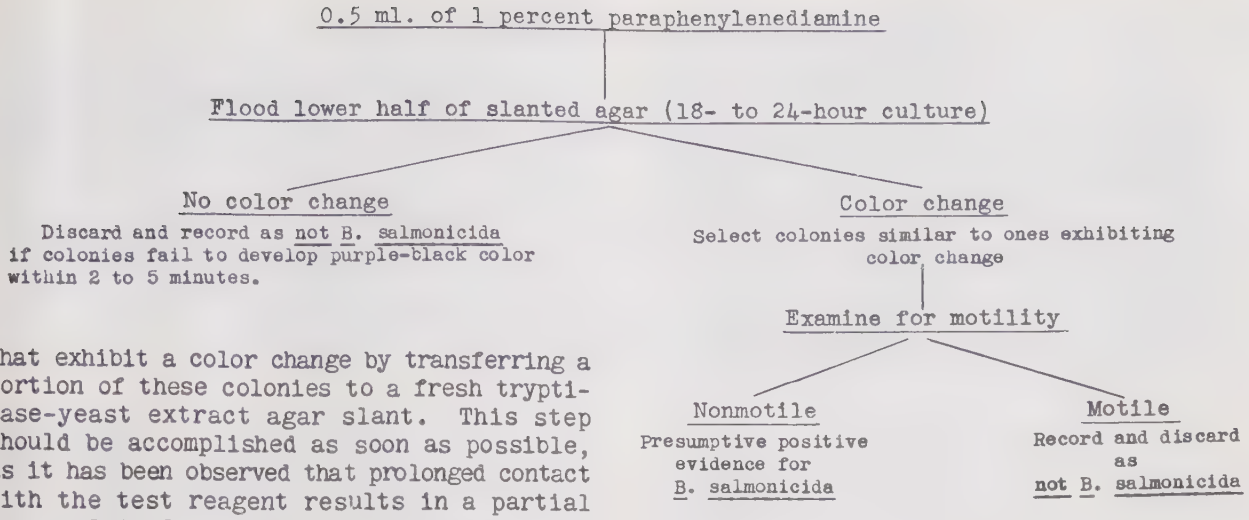
For Apparently Pure Cultures (All Colonies of Uniform Type)

A positive presumptive test for B. salmonicida is indicated by the following: (1) The colonies (not the surrounding medium) develop a color, changing from colorless to purple to purple-black within 45 seconds to 3 minutes. (2) Examination under the microscope (preferably in hanging drop) of microorganisms taken from the upper half of the slant (that portion of the slant containing colonies which did not come in contact with the test reagent) indicates that the organisms are nonmotile.

A negative presumptive test for B. salmonicida, indicating that furunculosis is not present in the suspect fish examined, is assured when (1) the colonies on the surface of the slant do not change color in the manner described but remain essentially colorless (under these circumstances a motility test is not required); or, (2) the colonies do change from colorless to purple or purple-black within the period of time described, but the microorganisms (taken from the upper portion of the slant) are also motile.

For Cultures Which Are Obviously Mixed (More Than One Colonial Type Evident by Visual Inspection)

Apply the test reagent as previously directed and isolate the various colonial types


0.5 ml. of 1 percent paraphenylenediamine
Flood lower half of slanted agar (18- to 24-hour culture)
No color change
Discard and record as not B. salmonicida if colonies fail to develop purple-black color within 2 to 5 minutes.
Color change
Select colonies similar to ones exhibiting color change
Examine for motility
Nonmotile
Presumptive positive evidence for B. salmonicida
Motile
Record and discard as not B. salmonicida

that exhibit a color change by transferring a portion of these colonies to a fresh trypticase-yeast extract agar slant. This step should be accomplished as soon as possible, as it has been observed that prolonged contact with the test reagent results in a partial or complete loss in the viability of most of the microorganisms tested. Incubate and perform the test as described under Methods. An alternative method is to choose a colony (from the upper half of the slant not treated with the reagent) which is similar in appearance to those which have undergone the color change described. Examine for motile microorganisms. If nonmotile, record these as "positive presumptive" for B. salmonicida. If motile, record as "negative" for B. salmonicida. Mixed cultures in which none of the colonies turn color after application of the reagent are, of course, recorded as negative.

DISCUSSION

At the time of writing, 81 cultures, isolated from diseased or dead fish of various types, have been tested by this method. Of this number, more than a quarter of the cultures were known strains of B. salmonicida.

In every instance, a differentiation could be made between those cultures which were known B. salmonicida and those cultures which were of other genera or species. However, this does not exclude the possibility that one may occasionally encounter microorganisms which are not B. salmonicida and which evidence a positive presumptive test on the basis of the method described in this report.

The possibility also exists of mixed cultures of B. salmonicida and other unrelated microorganisms which also evidence a positive presumptive test according to the criteria established in the present report. Under these circumstances, one must then employ other methods of identification. However, the ease and rapidity of the method, as well as the success thus far obtained in distinguishing B. salmonicida from other microorganisms, may reflect the general usefulness of the proposed schema. For clarity, the procedures used in the presumptive test are prescribed in the accompanying diagram.

REFERENCES

Griffin, P. J.; Snieszko, S. F.; and Friddle, S. B.
A new adjuvant in the diagnosis of furunculosis in fish caused by Bacterium salmonicida. /In preparation/

Gutsell, J. S., and Snieszko, S. F.
1948. Furunculosis in fish; its diagnosis and treatment. Vet. Med. 43 (11): 484-486.
1949. Dosage of sulfamerazine in the treatment of furunculosis in brook trout, Salvelinus fontinalis. Trans. Am. Fish. Soc. 76 (1946): 82-96.

A fishery administrator is a citizen who is expected to start with an indefinite, indeterminate number of unknown, variable natural factors--including the factor of human nature--and, without benefit of any recognizable formula or recipe, add these elements together to produce a constant, stable, unfailing, maximum supply of catchable, marketable or profitable fish or shellfish.--Milton C. James.

A COMPARISON OF THE GROWTH OF FINGERLING CHINOOK SALMON REARED IN PONDS, TROUGHS, AND CIRCULAR TANKS

Harlan E. Johnson and Alfred C. Gastineau
U. S. Fish and Wildlife Service
Anderson, California

AN EXPERIMENT was conducted at the U. S. Fish and Wildlife Service's Coleman Station at Anderson, California, during 1949 to compare the growth of fingerling fall chinook salmon (Oncorhynchus tschawytscha) reared in large concrete ponds, in hatchery troughs, and in small circular tanks for a period of 24 weeks. The experiment was part of a search for an improved method for estimating, periodically, the total weight of fish held in the rearing ponds.

An accurate estimate of the weight of fish on hand is required if effective use is to be made of feeding charts in which the amount to feed daily is given as a percentage of the total weight of the fish to be fed. The feeding chart in use at Coleman is a modified and interpolated version of the New York Feeding Charts for trout (Deuel, Haskell, and Tunison, 1942). Because of the large number and weight of fish involved, it is not feasible to weigh all of the stock at frequent intervals; therefore, it has been customary to use two methods for estimating the weight of fish in the ponds. The two methods are based upon "pilot troughs" and "pond sampling," and neither method has been entirely satisfactory. When pilot troughs are used, a small representative sample of the fish in the ponds is reared in hatchery troughs. These fish are weighed biweekly, and from their known weight an estimate is made of the weight of the salmon in the ponds. This method can be used only during the spring and early summer because the fall chinook salmon at the Coleman hatchery grow less rapidly in the troughs than in the ponds after the fish reach an average weight of about 8 grams (50 per pound). The second weight-estimation method, which is used after the data from the pilot troughs become unreliable, involves weighing and counting a selected sample of fish in the ponds to determine their average weight, from which the total weight is calculated. This method is laborious and time-consuming and also is subject to much error, as it is impossible to be certain that the sample of fish selected is representative of the entire lot.

A preliminary test conducted in 1948 with two small circular tanks indicated that the fingerling chinook salmon in the tanks grew at approximately the same rate during the entire summer as the fish held in the large rearing ponds. It appeared possible, therefore, that the tanks would prove satisfactory for replacing both pilot troughs and pond sampling. To confirm the original results, a more extensive experiment was designed for the 1949 rearing season.

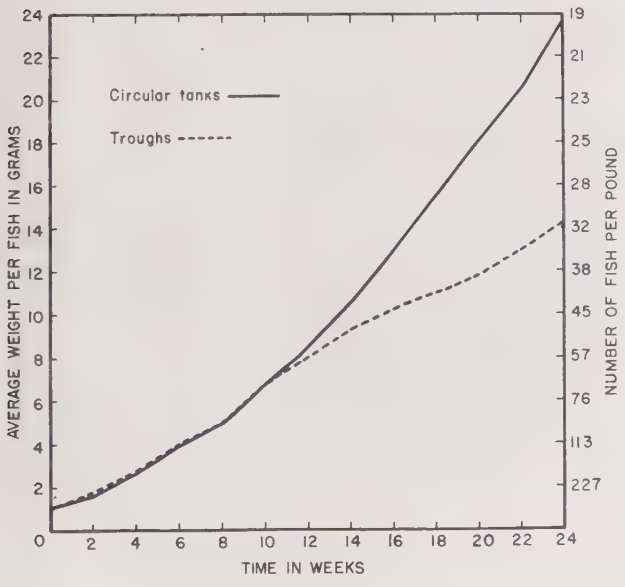
The rearing ponds used in the 1949 experiment had concrete sides and bottoms (140 feet long and 15 feet wide) and an average water depth of 26 inches. Each pond was supplied with about 675 gallons of water per minute. The troughs, which were in the hatchery building, were constructed of wood, were 16 feet long and 16 inches wide, and had an average water depth of 10 inches. The circular tanks were made of wood, had flat bottoms, center screen, and drain, and were located at the upper ends of the rearing ponds. The tanks were 6 feet in diameter and contained water 1 foot in depth. Each circular tank and trough was supplied with 10 to 12 gallons of water per minute. During the experiment (April to October) the temperature of the water ranged from 50° to 68° F., averaging about 60° F. for the period. All fish were fed the Coleman production diet.

On April 20-21, 1949, one lot of fall chinook salmon fingerlings was taken from hatchery troughs and distributed equally and at random into seven of the large rearing ponds. Each pond received about 70,000 fish weighing 175 pounds. At the time the transfer to ponds was made, a representative sample was withdrawn from the lot by means of a sampling device (Hewitt and Burrows 1948). Each of the six circular tanks used in the test was

Circular tanks used in the experiments.

Rearing ponds used in the experiments.

stocked with 500 salmon from the representative sample, and each of three troughs in the hatchery received 300 salmon from this sample. The fish in three of the seven ponds in the group were included in the experiment and were assumed to grow at the same rate as the fish in the circular tanks throughout the test. The salmon in the six tanks were weighed biweekly, and their average weight was used to compute the total weight of the fish in the three ponds. This computed total weight was used in determining the amount of food to be fed daily. The four remaining ponds in the group were used as the control; they were handled in the same manner as all other production stock at the hatchery, the growth of the fish being estimated from pilot troughs until June 29 and by pond sampling thereafter.


Circular tanks
Troughs
AVERAGE WEIGHT PER FISH IN GRAMS
NUMBER OF FISH PER POUND
TIME IN WEEKS
0 2 4 6 8 10 12 14 16 18 20 22 24
24 22 20 18 16 14 12 10 8 6 4 2
19 21 23 25 28 32 38 45 57 76 113 227

Average weight, at biweekly intervals, of fingerling chinook salmon reared in circular tanks and in troughs for 24 weeks.

The growth of the fingerling salmon reared in the six tanks and the three troughs, as determined by biweekly weighings, during the experiment is presented in the drawing. The growth of the salmon held in the rearing ponds is not included, as these fish were weighed only at the beginning and end of the test. It is apparent from the graph that the fish in the troughs and the circular tanks were growing at similar rates until the twelfth week, when the young salmon reached an average weight of more than 8 grams. Thereafter the growth of the fish in the three troughs was much retarded: at the end of the experiment the fish reared in troughs had an average weight of 14.22 grams, whereas the salmon in the circular tanks had an average weight of 23.81 grams. The reason for this difference in rate of growth is not understood, but it certainly was not the result of overcrowding in the troughs: when the experiment was terminated, the troughs contained only 0.53 pound of fish per cubic foot of water and the tanks had 0.95 pound per cubic foot of water.

The salmon in the ponds, tanks, and troughs were weighed and released on October 5, when the experiment was closed. These data are summarized in table 1. The average weight of the fish in the tanks was used to estimate the total weight of the fish in the ponds. This estimated total weight was 10,320 pounds. The actual weight, as determined by weighing the salmon in the three ponds, was 10,389 pounds, a difference of only 69 pounds or 0.6 percent. The fish in the three ponds had a final average weight of 23.91 grams, which was 0.10 gram greater than the average weight of the fish in the six tanks. The variations in growth made by the fish in the individual ponds and tanks were low. The

fish in the four control ponds, which were handled under the usual production procedures, had an average weight of 22.98 grams when released on October 6.

Statistical analysis of the data indicated that there was a highly significant difference between the mean weights of the salmon of both the ponds and the tanks when compared with the weights of the fish reared in the troughs. There was no significant difference between the mean weights of the fish in the ponds and the tanks.

The mortalities during the experiment were normal in the ponds and in the circular tanks. During June and July columnaris caused some losses in the ponds, but little evidence of this disease was observed in the tanks or troughs at that time. In the final 8 weeks of the experiment, the mortality of fish held in the troughs became abnormally high. Many of the dead and moribund fish had typical lesions of columnaris on the gills or body. This is a common experience at Coleman when large chinook salmon fingerlings are held in troughs.

TABLE 1.--Number of fish, average weights, and total percent mortality of fingerling chinook salmon reared in ponds, circular tanks, and troughs for 24 weeks

Rearing facility	Number of fish at start	Average weight, start	Average weight, end[1/]	Percent mortality
		(Grams)	(Grams)	
Three ponds	207,470	1.13	23.91	4.96
Six tanks	3,000	1.13	23.81	2.67
Three troughs	900	1.13	14.22	9.78

[1/]Least difference for significance at 5% level, 5.42 grams; at 1% level, 7.8 grams.

Conclusions

Fingerling fall chinook salmon held in circular tanks 6 feet in diameter for 24 weeks (April to October) grew at a rate comparable to that of salmon held in large rearing ponds. The circular tanks, therefore, are satisfactory for rearing a representative sample of chinook salmon from which the weight of the entire lot can be estimated accurately.

After they reached an average weight of about 8 grams, fingerling fall chinook salmon reared in hatchery troughs did not grow so rapidly as those reared in 6-foot circular tanks or in large ponds.

Literature Cited

Deuel, C. R.; Haskell, D. C.; and Tunison, A. V.
1942. The New York State fish hatchery feeding chart. N. Y. Cons. Dept. Fish. Res. Bull. 3. 38 pp.

Hewitt, G. S., and Burrows, R. E.
1948. An improved method for enumerating hatchery fish populations. Prog. Fish-Cult. 10 (1): 23-27.

CHLORETONE USED TO ANESTHETIZE SALMON FINGERLINGS

A TECHNIQUE for anesthetizing salmon fingerlings that are to be measured has been reported by Roger E. Burrows, chief of the Salmon Cultural Laboratory of the Fish and Wildlife Service at Entiat, Washington.

Fingerlings are put in a net suspended in a 1:2,500 concentration of chloretone. When swimming motion of the tail has ceased and the fish lie on one side (usually 2 to 3 minutes), they are removed from the solution and placed in a second net. This is put in fresh water, where they recover in 3 to 8 minutes. If some fingerlings recover from the anesthetic before they are measured, these may be replaced in the solution without harmful effects.

At this laboratory, the practice has been to make a gallon or more of the solution, use 1,600 cubic centimeters in the anesthesia container, add to that as the solution becomes weaker by dilution, and store the remainder.

C O R R E C T I O N

In "An Interim Report on Gill Disease" by R. R. Rucker, H. E. Johnson, and G. M. Kaydas (THE PROGRESSIVE FISH-CULTURIST 14 (1): 11-14), chinook should be substituted for blueback in the titles of tables 1 and 2 (pages 13 and 14).

RATE OF SURVIVAL OF LARGEMOUTH BLACK BASS FINGERLINGS STOCKED IN EXPERIMENTAL FARM PONDS

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SINCE THE OPERATION and drainage of a number of experimental ponds, which were stocked primarily to compare various ratios and species combinations involving largemouth black bass (Micropterus salmoides) fingerlings, a very important point has been brought to the attention of this author. Before it is possible to make any definite recommendations as to stocking ratios and species combinations for farm ponds, some idea as to the survival rate of the stocked species must first be determined. This applies especially to the predator species. The survival rate of the forage species is also important but, to a great extent, is compensated for by their prolificness in southern waters.

Project

This paper presents the results from eight experimental ponds at the A. E. Wood State Fish Hatchery, San Marcos, Texas. Other aspects of the results from these ponds were reported by Brown (1951). The ponds were operated during the period 1948-50. As noted in the table, all of the ponds were small (0.07 acre), with the exception of one pond which was 2.61 acres in size. A large number of Texas farm ponds have a surface of less than 0.25 acre.

In November 1948 the ponds were stocked with largemouth black bass fingerlings which were 4 to 5 inches in length, bluegill sunfish (Lepomis macrochirus) 1 to 1½ inches in length, and black crappie (Pomoxis nigromaculatus) 2½ to 3 inches in length. (All measurements refer to total length.)

As the A. E. Wood State Fish Hatchery was not yet in operation, the fingerling bass and bluegill sunfish were obtained from the U. S. Fish and Wildlife Service hatchery at Austin, Texas, and transported a distance of 31 miles to the State hatchery at San Marcos. The crappie were obtained from the Kerrville State Fish Hatchery.

The ponds were drained during the summer of 1950, and the fish were immediately sorted, counted, measured, and weighed. All of the ponds were operated approximately the same length of time (17 to 19 months), the majority being operated 18 months. None of the ponds were fished during this period.

Limitations

Since the results set forth represent the returns from only eight ponds, such results undoubtedly do not show a valid picture of survival from stocking largemouth black bass fingerlings in Texas farm ponds. Nevertheless, this is a starting point, and it will furnish valuable information for comparison with data from more ponds to be stocked in the future.

It would be possible to list many factors that might affect the survival rate of stocked bass fingerlings--factors such as the physical condition of stocked fish, distance the fish were transported and method of transportation, physical and chemical differences in stocked water and hatchery water, size of farm pond, number of the fish stocked per acre, number and kinds of forage fish stocked, and amount of natural food in the pond, as well as many other factors. Yet, some idea of the normal survival rate of stocked predator species may be obtained in experiments of this type.

Results

From study of the table it may be seen that the rate of survival of the bass fingerlings at the end of 18 months ranged from 47.1 to 83.3 percent, with a mean of 65 percent. Surber (1949) reported survival rates of 69.2 to 100 percent, the average being 83.0 percent, from stocking 1.9- to 3.5-inch fingerling bass. Some of Surber's ponds were stocked with fingerling bass-of-the-year which were 1.0 to 1.3 inches in length. The ponds

SURVIVAL RATE FROM STOCKING LARGEMOUTH BLACK BASS FINGERLINGS

Stocking ratio in fish per acre	Time pond ran (months)	Size of pond (acres)	Percent survival of bass fingerlings
125 bass 1,000 bluegill sunfish	18	0.07	83.3
125 bass 500 bluegill sunfish	18	0.07	83.3
250 bass	18	0.07	69.0
1/ 100 bass 1,500 bluegill sunfish	17	0.07	55.5
1/ 150 bass 100 bluegill sunfish	18	0.07	50.0
100 bass 100 bluegill sunfish 50 black crappie	19	2.61	47.1
Mean percent survival of bass fingerlings			65.0

1/ Average of two ponds.

operated by Surber ran approximately 6 to 15 months, and many of the fish were removed by fishing. The higher percentage survival reported by Surber (83.0), as compared with the 65 percent reported by this author, could be attributed, in part, to the shorter length of time Surber's ponds were operated, as well as to the fishing of his ponds before fish were removed by draining.

Smith and Swingle (1943) reported a survival rate of 75 percent for bass fingerlings in bluegill-bass combinations. The 75 percent survival rate may be higher than this author's 65 percent because Smith and Swingle reported on only one pond and it ran a shorter length of time (between 9 and 12 months). Other factors, also, could have influenced the lower survival rate received by this author. The ponds used were small (0.07 acre) and thus required few fish to stock; hence the loss of one fish had a much greater effect on the survival rate than such a loss would have had on ponds of 1 to 2 acres in size. Further, one pond used by this author had extremely low survival rates: only 33 percent for bass and 3 percent for bluegills. The bass survival rate was averaged with that from another pond stocked at the same ratio (77.7 percent) to give an average of only 55.5 percent for that particular stocking ratio.

In the eight ponds operated by this author, fertilization did not seem to influence the survival rate of bass fingerlings in any given direction. This conclusion, however, is very doubtful. The higher survival rates for the bass fingerlings were obtained at stocking ratios of 125 bass and 1,000 bluegills per acre, and 125 bass and 500 bluegills per acre. Both ratios yielded a bass survival rate of 83.3 percent. The pond stocked with only 250 bass per acre had a rather high survival rate (69.0 percent).

The results obtained from the ponds appear to indicate that a mean survival rate of 65 percent is rather close to the actual survival rate obtained, after a period of 1½ years, from stocking largemouth black bass fingerlings in Texas farm ponds, provided that no fishing pressure has been exerted. From all indications it seems that the over-all survival rate for a pond may be raised by fishing the pond as soon as possible after stocking; thus the harvest includes fish that may not be in the pond at a later date because of predation, disease, and other natural controls.

In stocking farm ponds, it is of the utmost importance to consider the survival rate of the fish stocked before any stocking procedure is adopted. Smith and Swingle very aptly stated (1943: 65) this author's convictions:

> Fish-culturists charged with stocking new ponds must take the percentage survival of planted fish into consideration if the ponds that they stock are to give good fishing within a reasonable period of time. If they assume that the percentage of survival in new ponds is low as it is in streams and lakes and overstock accordingly, then the fish cannot reach legal size and poor fishing results. If, on the other hand, they understock the pond with bluegills or bass or both, the pond is likely to be out of balance.

Literature Cited

Brown, W. H.
1951. Results of stocking largemouth black bass and channel catfish in experimental Texas farm ponds. Trans. Am. Fish. Soc. 80 (1950): 210-217.

Smith, E. V., and Swingle, H. S.
1943. Percentages of survival of bluegills (Lepomis macrochirus) and largemouth black bass (Huro salmoides) when planted in new ponds. Trans. Am. Fish. Soc. 72 (1942): 63-67.

Surber, E. W.
1949. Results of varying ratio of largemouth black bass and bluegills in the stocking of experimental farm ponds. Trans. Am. Fish. Soc. 77 (1947): 141-151.

EGG INVENTORY: ENUMERATION WITH THE EGG COUNTER

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Rome, New York

ALL METHODS OF EGG INVENTORY other than a total count involve two steps. The first step is a measure of the total quantity of eggs by weight or volume. Usually the eggs are measured in unit quantities, the unit often being the amount of eggs placed on a hatching tray or in a hatching box. The second step is a determination of the number of eggs per unit of weight or volume. This general method involves two sources of variation: (1) the variation from unit to unit in the components of the total measure, and (2) the variation in the samples taken to determine the number of eggs per unit. The accuracy, then, depends upon the accuracy of two techniques: the measurement and the sampling.

In an earlier issue of THE PROGRESSIVE FISH-CULTURIST, four methods of egg enumeration were compared (Burrows 1951). The present paper describes another method, which has been used by Haskell since 1946. This method employs a technique of measurement which has some advantages, but the principal departure from other methods lies in the sampling technique.

Total Measurement

The eggs are measured in a can which holds 24.5 ounces when filled level with the top (see figure). After the container has been filled, it is shaken to settle the eggs. Any excess eggs are wiped off in the same way the foam is wiped from a glass of beer. Each such unit is placed in a hatching box. The final result in measuring a lot of eggs, then, is a number of boxes containing equal quantities of eggs and one box containing a fraction of the unit amount.

For many inventories it would be desirable to have at hand several cans of various sizes.

Sampling

The sampling technique consists of a total count of the whole boxes. For a test of the method, single boxes may be counted to determine the variability in the original measure. In practice, the counting is accelerated by selecting five boxes at random from the lot, combining the eggs in a single box, and then counting the total. When a large number of eggs is involved, it is often desirable to count at least 3 lots of 5 boxes, or a total of 15. The number of eggs per box is the average of the counts. The total number of eggs is determined by multiplying the number per box by the number of full boxes and adding a count of the last, partly full box. This estimate requires no determination of the number of ounces of eggs, as the volume of the measuring container does not enter the calculations.

Counting

The egg counting is accomplished by means of a counting board described by Stack (1935: 13-14) as follows:

> The device used by the Paradise Brook Trout Company for counting brook trout eggs is of two separate pieces, made of hard rubber 3/16" thick. One measures 7" x 7-3/4" and has 500 one-quarter inch holes drilled half way through the rubber, and the hole is continued through the rubber with a 1/16" drill. The rows of holes are staggered and the holes measure 5/16" from center to center in each row.
>
> When using this device the eggs are floated over the counter which is then gently raised from the water in the egg container, and an egg naturally nests into each hole, the water drains through the small hole in the bottom, ...

Stack continues,

> ... We use another counter made as described above ... with five holes in a row and twenty rows, or 100 holes in all. ...

The latter was used for small numbers of eggs, as at the end of a count.

This device can be operated quite rapidly after a little experience. The counter is dipped into the eggs and a large excess of eggs is lifted. The counter is then tipped at a sharp angle over the box and jarred on the end of the handle. The excess eggs slide off.

Bakelite is an excellent material for such a counter.

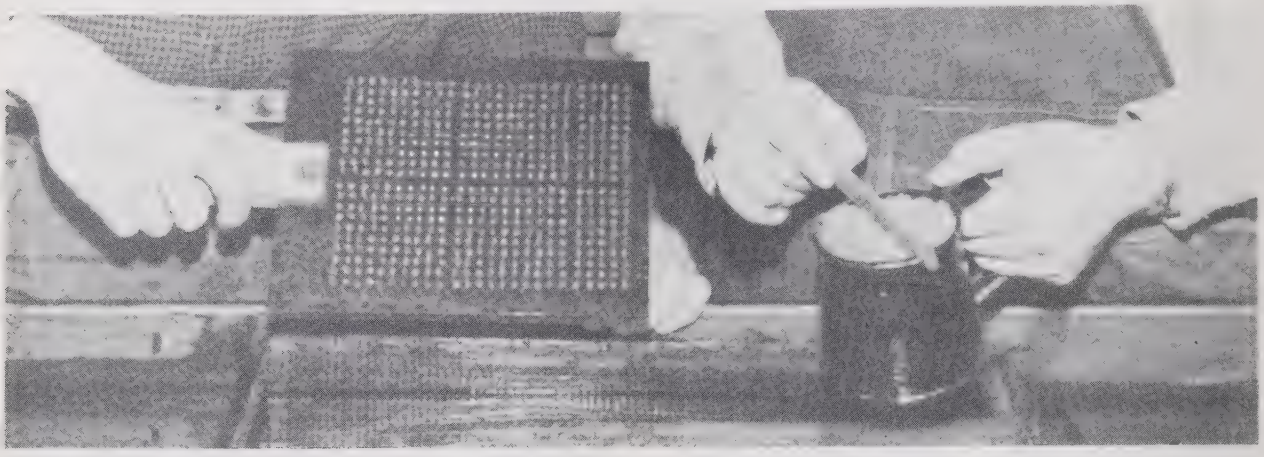
Conclusions

1. In enumerating eggs, it is extremely desirable that the unit used in measuring the eggs be the same as the unit of the samples, as this eliminates differences between the sampling and total measures.

2. Measurement by filling a container to the top eliminates some errors of judgment.

3. Use of the counting board eliminates the tedium of counting egg by egg and speeds the counting so that large numbers of eggs may be counted economically.

4. The method described gives a good estimate of the total number of eggs, though it may give only a fair estimate of the number of ounces of eggs and the number of eggs per ounce.



(Photo by John Freese.)

The egg counter and a container used for measurement.

Accuracy

During the preparation of this article, the data were taken on rainbow eggs which were about 400 to the ounce. Ten individual boxes were counted to determine the variation in the method of measurement, and five combined boxes were counted to determine the time required. The data are as follows:

Individual counts of 10 boxes:
9,750, 9,967, 9,950, 9,875, 9,941,
9,833, 10,020, 9,692, 9,590, 9,669

Fiducial limits of egg enumeration:

	if 5 boxes are counted	if 15 boxes are counted
5% level	± 1.48%	± 0.85%
1% level	± 2.11%	± 1.22%

Man-hours required for:
measuring 1,000,000 eggs ----3 hrs.
counting 5 boxes ----------1 hr.

The data on accuracy cannot necessarily be applied to other eggs, because eggs which are quite uniform should give a higher degree of accuracy than eggs which vary over a considerable size range.

Acknowledgment

The egg container and the technique for its use were developed by Charles Mykel, foreman of the Warrensburg Hatchery. The egg counter used at Rome was made by Alan Rand.

Literature Cited

Burrows, R. E.
1951. An evaluation of methods of egg enumeration. Prog. Fish-Cult. 13 (2): 79-85.

Stack, George, and Nichols, K. B.
1935. On counting eggs. Fish Culture 1 (3): 12-14. N. Y. Cons. Dept.

CLEARING HOUSE

Salmon research at Deer Creek, California.--F. K. Cramer and D. F. Hammack.
Spec. Sci. Rept., Fisheries No. 67. 16 pp. January 1952. (processed)
- Fish and Wildlife Service
Interior Building
Washington 25, D. C.

Breeding habits of lake trout in New York.--W. F. Royce.
Fish. Bull. 59 (Fish. Bull., Fish and Wildlife Service 52: 59-76). 1951. 20¢.

Characteristics of spawning nests of Columbia River salmon.--C. J. Burner.
Fish. Bull. 61 (Fish. Bull., Fish and Wildlife Service 52: 97-110). 1951. 20¢.

Unique bacterium pathogenic for warm-blooded and cold-blooded animals.--P. J. Griffin and S. F. Snieszko.
Fish. Bull. 68 (Fish. Bull., Fish and Wildlife Service 52: 187-190). 1951. 10¢.

Estimation of size of animal populations b marking experiments.--M. B. Schaefer.
Fish. Bull. 69 (Fish. Bull., Fish and Wildlife Service 52: 191-203). 1951. 15¢.
- Superintendent of Documents
Government Printing Office
Washington 25, D. C.

Life history and management of the mountain whitefish, Prosopium williamsoni (Girard), in Logan River, Utah.--W. F. Sigler.
Bull. 347. 21 pp., illus. May 1951.
- Agricultural Experiment Station
Utah State Agricultural College
Logan, Utah.

Some aspects of the physiology of fish.--W. S. Hoar, V. S. Black, and E. C. Black.
Univ. Toronto Biol. Series No. 59 (Publ., Ontario Fish. Res. Lab. 71). 111 pp. 1951.
- University of Toronto Press
Toronto, Canada.

Sea lamprey investigations. II. Egg development, maturity, egg production, and percentage of unspawned eggs of sea lampreys, Petromyzon marinus, captured in several Lake Huron tributaries.--V. C. Applegate.
Mich. Acad. Sci. Arts, and Lett. 35: 71-90. 1951.

Movement and dispersion of a blocked spawning run of sea lampreys in the Great Lakes.--V. C. Applegate and B. R. Smith.
Trans. N. Am. Wildl. Conf. 16: 243-251. 1951.

Status of lake trout fishery in Lake Superior.--Ralph Hile, P. H. Eschmeyer, and G. F. Lunger.
Trans. Am. Fish. Soc. 80 (1950): 278-312. 1951.

Trends in the lake trout fishery of Lake Huron through 1946.--Ralph Hile.
Trans. Am. Fish. Soc. 76 (1946): 121-147. 1949.

Progress report on the study of Great Lakes trout.--John Van Oosten.
The Fisherman. 18 (5,6): 5-8, 10. 1950.
- Great Lakes Fisheries Investigation
Fish and Wildlife Service
Ann Arbor, Michigan.

The Indian dip net fishery at Celilo Falls on the Columbia River.--R. W. Schoning, T. R. Merrell, Jr., and D. R. Johnson.
Contrib. 17. 43 pp., illus. November 1951.
- Oregon Fish Commission
Portland, Oregon.

Discrimination of stream odors by fishes and its relation to parent stream behavior.--A. D. Hasler and W. J. Wisby.
Am. Naturalist 85 (823): 223-238. 1951.
- Department of Zoology
University of Wisconsin
Madison, Wisconsin

Construction and management of Kansas ponds.--O. W. Tiemeier, Seth Way, and Roy Schoonover.
Bull. 9. 36 pp. 1951.
- Forestry, Fish and Game Commission
Pratt, Kansas.

Biological observations and toxicity bioassays in the control of industrial waste disposal.--Peter Doudoroff.
Proc. 6th Industr. Waste Conf.
Purdue Univ. Engin. Bull.
Ext. Series 76 (Vol. 35, No. 6):
88-104. 1951.
- Federal Security Agency
Public Health Service
Environmental Health Center
Cincinnati, Ohio.

The closed season in warm-water fish management.--G. I. Murphy.
Trans. N. Am. Wildl. Conf.
15: 235-251. 1950.

The creel census in the national parks of Canada.--V. E. F. Solman.
Trans. N. Am. Wildl. Conf.
16: 225-232. 1951.
- Wildlife Management Institute
Wire Building
Washington 5, D. C.

Freshwater fish and fishing in native North America.--Erhard Rostlund.
Univ. Calif. Publ. in Geog.
Vol. 9. 314 pp., 47 maps.
January 1952. $3.50.
- University of California Press
Berkeley and Los Angeles
California.

The direct effect of turbidity on fishes.--I. E. Wallen.
Biol. Series 2, Vol. 48, No. 2.
27 pp., illus. 1951.
- Oklahoma A. and M. College
Stillwater, Oklahoma.

The natural foods of kamloops trout (Salmo gairdneri kamloops).--W. A. Clemens
Rept. Proc. Ann. Game Conv.
5: 75-80. 1951.
- British Columbia Game Commission
567 Burrard Street
Vancouver 1, British Columbia.

MILTON C. JAMES RETIRES

MILTON C. JAMES, Assistant Director of the Fish and Wildlife Service since September 1945, retired on March 31, 1952, after more than 30 years of Federal service in fisheries work.

"It is like losing my right arm to see 'Milt' retire," stated Director Albert M. Day, "but he has his mind set on retirement, so I am wishing him the best of everything. I will probably still bother him occasionally for advice."

Mr. James prepared, or assisted in the preparation of, a number of scientific papers. Among those that were published by the Fish and Wildlife Service, "Propagation of Pondfishes" and "Fish Stocking As Related to the Management of Inland Waters" were particularly effective in filling a very urgent need.

JOHN L. KASK, NEW ASSISTANT DIRECTOR

DR. JOHN L. KASK, whose appointment as Assistant Director of the Fish and Wildlife Service became effective April 1, has a record of successful experience equalled by very few in the field of fishery management and research.

Prior to his first assignment in the Fish and Wildlife Service as assistant director of its Pacific Oceanic Fishery Investigations, Dr. Kask studied fisheries in nearly every important fishing country in the world as chief biologist of the Fisheries Division of the FAO of the United Nations.

Dr. Kask has had a lifelong interest in fish culture. He has studied the highly developed Asiatic food-fish culture, which predates by centuries the fish-pond program in the United States.